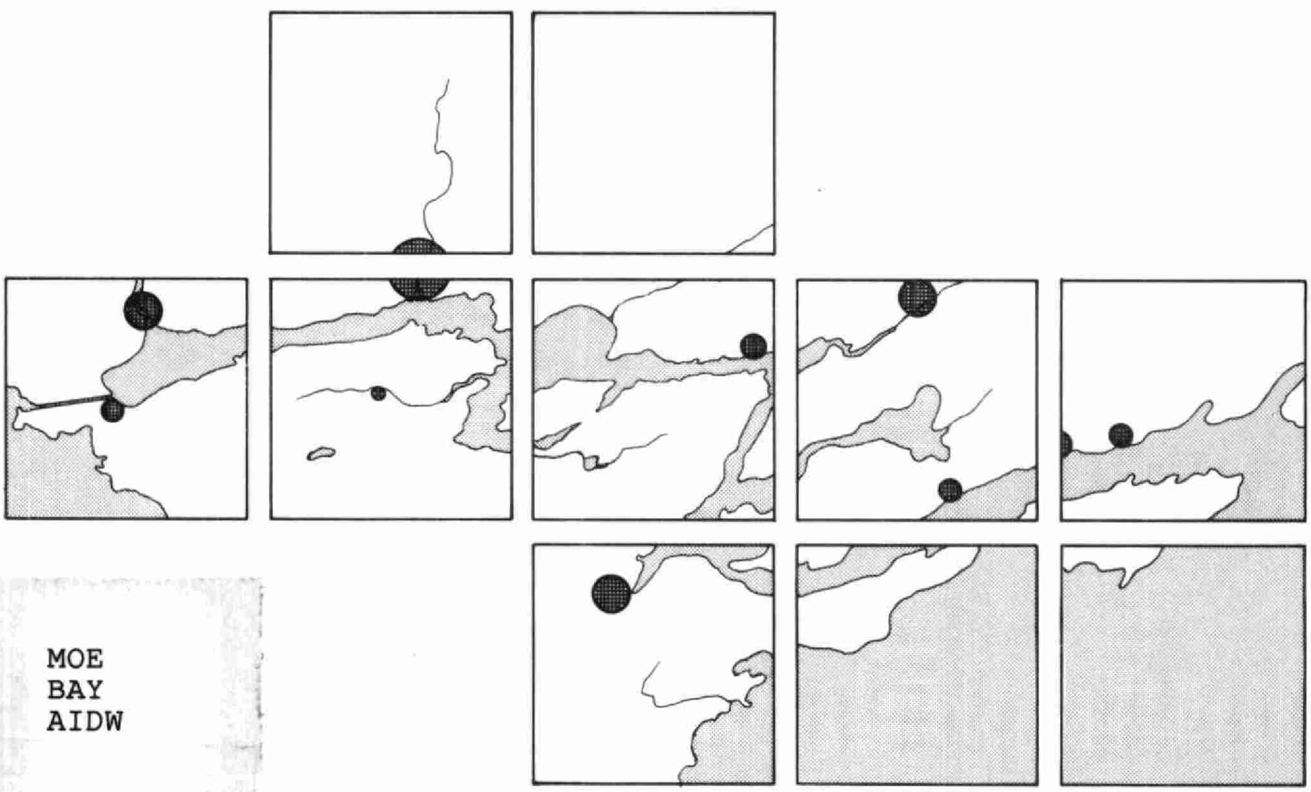
Bay of Quinte Remedial Action Plan

1987 Bacteriological Water Quality at Trenton, Deseronto and Picton Bay of Quinte



Technical Report No..5

BAY OF QUINTE REMEDIAL ACTION PLAN

1987 BACTERIOLOGICAL WATER QUALITY AT TRENTON, DESERONTO AND PICTON BAY OF QUINTE

prepared for:

THE BAY OF QUINTE RAP COORDINATING COMMITTEE

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FOREWORD

In its 1985 report to the International Joint Commission (IJC), the Great Lakes Water Quality Board recommended that the appropriate jurisdictions prepare and submit detailed Remedial Action Plans (RAPs) for the restoration of beneficial uses of 42 identified 'Areas of Concern' on the Great Lakes System. The Bay of Quinte is one of the IJC identified 'Areas of Concern'.

The process of developing a RAP for the Bay of Quinte was initiated in 1986 with the formation of a Federal/Provincial Coordinating Committee to oversee preparation of the RAP.

The Coordinating Committee in its February, 1987, Progress Report defined excessive nutrient enrichment, persistent toxics and bacteriological contamination as the factors responsible for the impairment of Bay of Quinte beneficial uses. It also identified technical data gaps and a list of potential options which required study.

This is one of a series of follow-up technical reports. It provides the findings of a bacteriological water quality study of the Bay of Quinte undertaken during 1987. The purpose of the study was to re-examine and update the status of bacteriological contamination in the vicinity of Trenton, Deseronto and Picton. Earlier bacteriological conditions at these locations have been documented in a 1984 Ministry of the Environment report. The findings of a similar bacteriological investigation in the vicinity of Belleville have been documented in a 1986 Ministry of the Environment report.

It should be noted that this report is only intended to serve as a background reference document. It provides much useful information that will assist the Coordinating Committee and the public in evaluating the degree of bacteriological water quality impairment, the causative factors and the required corrective measures. The Bay of Quinte Remedial Action Plan when completed will contain a summary of the available bacteriological water quality data, identify the causes and a define the remedial measures required to overcome the bacteriological problems in the Bay.

January, 1989

Bay of Quinte RAP Coordinating Committee

1.0 BACKGROUND AND SUMMARY

1. At the mouth of the Trent River in Trenton, the largest zone in which 2-sample daily geometric means exceeded the Provincial Water Quality Objective of 100 fecal coliforms (FC)/100 mL extended about 1 km into the Bay. This was significantly smaller than the largest bacterial zone found in 1981 by Griffiths (1984). Comparison of dry weather data with data obtained after a 16 mm rainfall indicated no significant wet weather increase during 1987 surveys.

2. Both Domtar Packaging Ltd. and Trent Valley Paperboard were found to be sources of Klebsiella spp. The plume of high Klebsiella values extended into the Bay in a southwesterly direction, with values about 100 organisms/100 mL being detected as far as 3 km from the Trent River mouth. The concentration of Klebsiella organisms in the Domtar Packaging Ltd. outfall varied considerably from day to day, with a low of 10^4 organisms/100 mL and a high of 8.1×10^7 organisms/100 mL. However it should be noted that no evidence has been found to relate Klebsiella to human illness in several occupational and environmental studies.

3. The high Klebsiella levels in the lower Trent River and near the mouth of the Bay interfere with the accuracy of the fecal coliform test. However, not all Klebsiella form colonies in the FC test; the ratio of Klebsiella counts to excess FC above the E. coli count varies from about 10 to several hundred. This is because many Klebsiella do not have the same ability to grow at 44.5°C, the temperature used in the fecal coliform test; therefore only a variable portion of the Klebsiella are counted.

4. The Domtar effluent was also a source of E. coli, with 2-sample daily geometric means ranging from 1.7×10^3 to 1.5×10^6 organisms/100 mL. Studies in 1984 suggested that the log bark wash waste stream was the source of sanitary contamination.

5. The Trenton STP effluent is a source of fecal coliform bacteria including both E. coli and Klebsiella. Daily geometric mean levels ranged from 60 to 2.6×10^5 E. coli/100 mL and 370 to 4.6×10^5 Klebsiella/100 mL. Any plume from this plant, however, was confined within a few hundred meters of the effluent pipe, and was small compared to the Trent River plume.

6. Effluent quality at the Trenton CFB STP was generally good, with only two of 8 daily geometric means exceeding 100 fecal coliforms/ 100 mL.

7. E. coli results at the mouth of the Trent River are generally higher than those at a transect about 1 km upstream. Results are similar in either dry or wet weather. This suggests possible illegal cross-connections or inflow/infiltration of sanitary sewage into storm sewers in downtown Trenton.

8. Water quality at the Bain Park beach at the east end of Trenton was acceptable on six of the eight survey dates. Elevated bacterial levels were found after rainfall on August 30 and 31, but no obvious source of this contamination was evident.

9. Water quality in the beach and nearshore areas of Deseronto was always excellent, with no evidence of impacts from the Deseronto STP or the (closed) Arctic Gardens food processing plant. A zone of high bacterial levels, however, did occur after a rainfall in mid-bay extending from the mouth of the Napanee River.

10. In Picton Bay, bacteriological contamination was generally confined to within a few hundred meters of Picton Marsh Creek. The zone of contamination increased slightly in size after rainfall; however the maximum wet weather bacteriological zone was smaller to that found in 1981.

11. The Picton STP generally had a very high quality effluent. Only on one survey day (immediately after rainfall) was the bacterial level high, at 1360 FC/100 mL. This may have contributed to the increased bacteriological zone in Picton Bay; however, overflows (e.g. at the large culvert in the park above Picton STP), stormwater input and inflow/infiltration may also be important.

12. Effluent quality at Picton Heights STP is generally poor, with daily geometric fecal coliform levels exceeding 100 FC/100 mL on all but one survey day and reaching a maximum of 2.9×10^4 FC/100 mL. The impact of this discharge appears to be confined to the upper reaches of Picton Marsh Creek, however.

13. Water quality at North Port Beach was always acceptable, with daily geometric means ranging from less than 4 to 40 FC/100 mL.

2.0 INTRODUCTION

Bacteriological pollution of the Bay of Quinte has been recognized to exist since 1970 when a survey of 28 locations representative of recreational and urbanized areas throughout the Bay (Hudgin, 1971) was carried out. Highest levels of pollution were found in the urbanized areas, particularly Picton and Deseronto. This report stated that these two areas were both influenced by sewage discharges, which at that time were untreated at Deseronto. Fecal coliform levels were highly variable in Trenton and Belleville, with at least one sample from each location exhibiting fecal coliform levels above 1000/100 mL. It was concluded that bacterial levels throughout the Bay were sufficiently high that caution was needed for swimming and bathing, and that Bay of Quinte water should not be consumed without adequate treatment or disinfection.

In 1981, a bacteriologial survey was conducted by the Great Lakes Section (Griffiths, 1984) at Trenton, Belleville, Picton and Deseronto. The purposes of this survey were to document STP and river bacterial sources, assess impacts of these sources on recreational waters and recommend remedial measures. Additional samples were taken in 1982 and 1984 by the MOE Southeastern Region in the lower Trent River.

In 1984 and 1985, a detailed bacteriological survey was conducted in Belleville (Poulton, 1986). The purposes of this survey were to document the impact of Belleville STP expansion on bacterial levels in the Bay, as well as to assess the magnitude of other inputs such as storm sewers on bacteriological water quality in the lower Moira River and adjacent Bay of Quinte. In addition to these surveys, the Hastings and Prince Edward Counties Health Unit collected samples at area beaches throughout most summers.

At Trenton, zones with fecal coliform levels >100/100 mL extended up to 2 km from the Trent River mouth into the Bay of Quinte, under dry

weather conditions as well as after rainfall. The plume did not appear to be related to discharges from the Trenton City or Canadian Forces Base STPs. The dry weather results suggested the presence of illegal cross-connections, bypassing, or other unknown sources. Surveys conducted in 1982 found the highest fecal coliform counts occurred downstream of the Domtar pulp and paper mill discharge. However, these surveys did not address the nature of the bacterial contamination near the Domtar discharge. Concern has been expressed about the possible existence of Klebsiella pneumoniae in the Domtar effluent; presence of this organism may account for the high fecal coliform counts observed at this location.

In 1984, a followup survey was conducted by the Southeastern Region (MOE, unpublished data) to address this concern. Effluent and river samples were analyzed for fecal coliforms, E. coli and Klebsiella pneumoniae. On July 24, 1984 in the vicinity of the Domtar outfall, high bacterial levels were found: 166-48,000 FC/100 mL; 130-15,000 E. coli/100 mL; and 166-16,000 Klebsiella/100 mL. These diminished gradually towards the mouth of the Trent River. By contrast, on July 31, levels of all these parameters were much lower, with the maximum levels near the diffuser being 160 FC/100 mL, 48 EC/100 mL and 112 Klebsiella/100 mL. It was suggested that the discharges from the Domtar plant were intermittent in nature, and that both process wastes and sanitary sewage were being discharged (due to the high levels of both E. coli and Klebsiella). In-plant studies suggested that the log bark wash stream was the source of the sanitary contamination. It was recommended that in-plant sanitary wastes be separated from process wastes so that simlar discharges would not continue to occur. Further tests in October 1984, after replacement of a defective septic tank within the plant, continued to indicate high E. coli levels of unknown origin.

At Belleville, the zone with fecal coliform levels >100/100 mL extended eastward along the Bay waterfront up to 3 km following a 15 mm rainfall in August 1981. It was suggested that raw sewage was being bypassed from the Belleville STP to the Moira River at the Dundas St. pumping

station, due to limited capacity to handle runoffs. Studies in 1984-85 addressed the problem of bacteriological contamination at Belleville in more detail (Poulton, 1986). These showed that the size of the wet weather plume was similar to that observed in 1981. In addition, the major bacteriological inputs to the Bay of Quinte in this region were shown to originate from storm sewers draining into the Moira River, both in the city and at the Corby Distilleries Ltd., north of the city.

At Picton, zones with FC >100/100 mL were attributed to storm and combined sewage discharges rather than to the chlorinated effluent from the Picton STP. At Deseronto, only occasional samples of FC >100/100 mL were found. Although no impairment from STP discharges was found, there was some suggestion that the effluent from Arctic Gardens Limited (food processing) contributed to increased fecal coliform counts sometimes found at Centennial Park beach. Since then, this company has ceased operations.

Samples have been collected on an irregular basis by the Hastings and Prince Edward Counties Health Unit from up to 3 beaches in Trenton plus the Centennial Park beach in Deseronto. Table 1 gives a summary of Health Unit data between 1982 and 1987.

At Trenton, the most frequently sampled location was Bain Park, which is located on the bayfront near the east city limits, downstream of the Trenton STP. Three out of four instances when the geometric mean exceeded 100 FC/100 mL in 1984 occurred on the day of rainfall or the day after; the only one occurrence (out of six sampling dates) in 1986 was also during a rainfall event. The other locations sampled in 1986 were Front St. (west side of river) and Centennial (near the STP at the mouth of river, east side). These were only sampled three and two times, respectively, in 1986 with one daily 5-sample geometric mean >100 FC/100 mL at each location. However, these exceedences were not associated with rainfall events.

By contrast, Frankford Beach (about 7 km upstream of Trenton) was highly polluted, with a 1986 geometric mean of 250 FC/100 mL and 5 daily

5-sample geometric means out of 8 exceeding 100 FC/100 mL. Interestingly enough, the highest bacterial levels did not appear to be correlated with rainfall. In 1987, every daily 5-sample geometric mean exceeded 100 FC/100 mL, with an overall geometric mean of 480 FC/100 mL.

At Deseronto, the highest daily geometric mean in 1986 was 60 FC/100 mL; however, samples were only collected on four dates. In 1987, the highest daily geometric mean was 84 FC/100 mL; again, samples were only collected on four dates, with three of the 20 individual samples exceeding 100 FC/100 mL.

The public involvement program of the Bay of Quinte RAP, initiated with a questionnaire in fall 1986 and a public meeting in January 1987, revealed several concerns related to bacteriological quality in the Bay of Quinte area. As well as general comments including bacteriological concerns, the need to clarify the extent and type of pollution from municipal sources, and suggestions that inputs to the Bay should be stopped altogether, a few specific comments were received, including the following: a Picton councillor claimed that there haven't been any combined sewer systems in Picton for 15 years. One stakeholder suggested that the Picton Heights STP should be upgraded. Beach closures on the one hand, and the lack of beach monitoring on the other, were mentioned. In this context, concerns about the water quality of Sophiasburg (North Port) and Adolphustown beaches were mentioned.

In the initial summarization of data for the Bay of Quinte RAP, the RAP Co-ordinating Committee decided that further investigations were required at Trenton, Deseronto and Picton. More specifically, it was decided to: (a) confirm bacterial inputs and their nature (fecal or non-fecal) to the Trent River from the Domtar mill; (b) reassess the bacteriological quality of waters in the vicinity of Centennial Park Beach in Deseronto; and (c) reassess the bacteriological quality of Picton Bay to determine the need, if any, for further source reductions.

The 1987 Bay of Quinte bacteriological survey was designed to provide an update of bacteriological conditions in Trenton, Deseronto and Picton, including the above-noted items. The results of this study, as well as 1984-85 studies at Belleville, will help to determine remedial efforts necessary to meet bacteriological water quality objectives.

3.0 SURVEY DESIGN

The grid of sampling stations used at each location was based on the original 1981 survey (Griffiths, 1984). It was modified to provide a greater density of sampling stations close to river mouths and beaches, as well as inclusion of upstream sampling locations on the Trent River and Picton Marsh Creek, and sampling of the effluents at Trenton STP, Trenton CFB-STP, Picton STP, Picton Heights STP and Domtar Wood Preserving Ltd. As a result of a local concern expressed during the RAP public involvement program, samples were also collected from North Port Beach on the south side of the Bay between Belleville and Deseronto. The sampling grids used are shown in Figures 1-4.

The survey was conducted in two phases: a preliminary survey in June-July 1987 and an intensive survey in August-September 1987. Survey dates and rainfall data for both phases are given in Table 2. During the preliminary survey, samples were collected for two days at each of Trenton, Deseronto and Picton. This phase proceeded irrespective of rainfall conditions; as it happened, a 2.8 mm rainfall occurred at Trenton immediately prior to the first survey day (Table 2), and the remaining days were dry. The survey was intended to provide a "shakedown" of field procedures, as well as establishing both field and laboratory capabilities and providing preliminary data for the purpose of optimization of the survey grids. At all locations used, duplicate samples were collected and analyzed for fecal coliforms and E. coli. At Trenton, samples were also analyzed for Klebsiella pneumoniae. During this time period, all samples were analyzed at the Ministry's Toronto laboratory.

The intensive phase consisted of sampling for three dry days and three wet days per location (the three wet days were constituted as consecutive days following a rainfall, i.e. day of rainfall plus next two days). Owing to the low bacterial levels observed at Deseronto in the June survey, no intensive dry weather survey was performed at this location; however, samples were collected at Centennial Park Beach in Deseronto (stations 437 and 438) during the Picton dry weather survey. Additional stations were added to the grid at Trenton (upstream Trent

River stations 15-106 to 15-114) and in the Bay south of Trenton (stations 453-460) due to the high Klebsiella levels observed north of the Domtar outfall and in the Bay south of Trenton during the June survey (see Section 4.1). One additional station (15-89) was also added on Picton Marsh Creek at Cemetery Street (see Section 5.3). Due to limited laboratory capacity in this time period, the analytical load was split between the Ministry laboratory and Ryan Analytical Laboratories. In past Ministry studies, data from Ryan Laboratories compared favourably with Ministry data (M. Young, pers. comm.); for confirmation, replicate samples were collected at each Trenton location on August 11 and 12, with one set analyzed at each laboratory. The laboratory used on each survey date is identified in Table 2.

4.0 RESULTS AND DISCUSSION

Results for the various survey dates and locations are shown in Figures 5 to 28. Methods of data presentation are similar to those used in reporting the Belleville and Kingston surveys (Poulton, 1986, 1987). Nearly all data presented are geometric means of two samples per location. It should be emphasized that the Provincial Water Quality Objective (PWQO) for the protection of body contact recreation of 100 fecal coliforms (FC)/100 mL should be applied to the geometric mean of a series of 10 or more samples per month and the zones shown in the various figures of this report depict 2-sample geometric means as a method of illustrating zones of potential impairment.

The Aquatic Ecosystems Objectives Committee in 1983 recommended to the Science Advisory Board of the International Joint Commission that the E. coli geometric mean level in receiving waters should not exceed 23 organisms/100 mL for protection of human recreational users of nearshore waters from increased gastrointestinal illness. This value has therefore been used throughout the report as a further indication of potential zones of bacterial impairment.

4.1 Trenton

In June, two days of data were obtained. These data represented conditions following a light (2.8 mm) rainfall within the 24 hours previous to the initial sampling (Table 2). In August, three days of dry weather data and three days of wet weather data were obtained; a total of 16.1 mm of rain was recorded within the 48 hours prior to the start of survey (Table 2), and a further 5.6 mm of rain occurred on the last survey day, according to data recorded at CFB Trenton.

4.1.1 Receiving Water and STPs

Figures 5-7 show results obtained in June for fecal coliforms, E. coli and Klebsiella pneumoniae respectively. Data for August are given in Figures 8-10 for the dry weather survey and Figures 11-12 for the wet survey.

In June, both parameters indicated a zone of impairment extending bayward several hundred metres from the mouth of the Trent River and another zone offshore of the Trenton STP outfall. Bacterial levels at the Bain Park beach were low to non-detectable. The impairment zones were slightly greater just after the rainfall (June 22) than on the next day.

Interestingly, the zones of FC >100/100 mL and EC >23/100 mL observed during the August survey period were somewhat larger during the dry weather period (Figures 8-9) than in the wet weather period (Figures 11-12). The exception to this is at Bain Park beach, which recorded elevated bacterial levels on August 30 and 31. No obvious source of these high bacterial levels is evident, as all surrounding locations, including the Trenton CFB-STP effluent, had low (generally below 20 organisms/100 mL) bacterial counts. Possible sources could include bathers or bird contamination, or eastward transport from the Trenton STP (which could have been closer to shore than Station 444 (Figure 1)).

Health unit data collected in 1987 at Bain Park indicated that the 5-sample daily geometric mean exceeded 100 FC/100 mL on only one survey date (July 22), out of a total of 7 dates sampled. Eight of 35 individual samples exceeded 100 FC/100 mL, with an overall geometric mean of 34 FC/100 mL. While some rainfall did occur before July 22, the amount involved was minor (3 mm on July 20) and was therefore of minimal significance. On one occasion (August 12) the beach was sampled by both the MOE and Health Region crews. The agreement between the two sets was good (Health Unit = 51 FC/100 mL; MOE = 38 FC/ 100 mL).

The largest bacteriological zone of FC >100/100 mL (August 12) extended about 1 km into the Bay, and was similar in size to the zones observed on 3 of the 6 survey dates in 1981 (Griffiths, 1984), and significantly smaller than that found on a fourth survey (August 24; Griffiths, 1984, Figure 12), where the outer limit of the bacterial zone was not defined by the survey grid. As in 1987, no direct correlation with precipitation was found with the largest zone being found under "trace" precipitation conditions. Maximum bacterial levels in the Trent River mouth in 1987 (260 FC/100 mL at Station 347 on August 31) was considerably levels than the 500 to above 1000 FC/100 mL found twice in August 1981.

Daily 2-sample geometric means for the Trenton STP and Trenton CFB-STP effluents are also given in the various figures. These show that the Trenton STP effluent is a source of fecal bacteria, including both E. coli and Klebsiella. Daily geometric mean levels ranged from 60 to 2.6 x 10^5 E. coli/100 mL and 370 to 4.6 x 10^5 Klebsiella/100 mL. The overall geometric mean bacterial levels were 860 FC/100 mL, 600 EC/100 mL and 1000 Klebsiella/ 100 mL (six survey days). A small plume of elevated bacterial levels extended up to about 0.4 km from shore at the Trenton STP on several of the survey dates (Figures 5,6,8,9). Its size was always small compared with the main Trent River plume, however, and no impact on any beach areas was evident.

By contrast, the effluent quality at the Trenton CFB STP was generally good. Over the survey period (eight survey days), the geometric mean bacterial levels were 43 FC/100 mL, 42 EC/100 mL, and 27 Klebsiella/100 mL. Only two of the 8 daily geometric means exceeded 100 FC/100 mL (6.0 x 10^6 FC/100 mL on June 25 and >300 FC/100 mL on August 13, both dry weather days). Only on August 13 was an impact on the Bay noticeable, and then only at the station nearest the end of pipe (Figure 8,9).

4.1.2 Trent River and Domtar

Figures 13-15 show results obtained in June for fecal coliforms, E. coli and Klebsiella pneumoniae respectively. Corresponding data for August are given in Figures 16-18 for the dry weather survey and Figures 19-20 for the wet weather survey. Due to analytical problems (Sections 3.0 and 4.1.3) wet weather Klebsiella data are not available.

During both the June (light precipitation) and dry weather August surveys, the E. coli density at the Trent River mouth (Stations 15-91,92,93) was considerably higher than at Dixon Drive (Stations 15-94,95,96) (Figures 14 and 17). This suggests inputs of human and/or animal fecal wastes from the downtown area of the city. Similar inputs to the Moira River in Belleville have been found to occur under both wet and dry conditions (Poulton, 1986), and suggest the presence of illegal cross-connections between the storm and sanitary sewers or possible inflow and infiltration into the storm sewer systems. According to Canviro (1987), the storm and sanitary sewer systems in Trenton were completely separated by 1980 and the sewage pumping stations possess standby capacities adequate to prevent bypassing to the river under all normal conditions. However, they do suggest illegal cross-connections may exist in the east end of the city but do not mention the downstream area. Further studies are needed to clarify the location and nature of inputs in this area.

As in the Bay, Trent River fecal coliform and E. coli results were similar in the dry and wet weather periods in August (Figures 16-17 and 19-20). The Domtar Packaging Ltd. effluent was found to be a source of E. coli with 2-sample geometric mean levels as high as 8.7×10^5/100 mL in dry weather and 1.5×10^6/100 mL on the day after rainfall. These high bacterial levels were reflected in the river data at Stations 15-100 and 101 on the east side of the river immediately downstream of the plant, and possibly also at station 15-96 on August 12, 29 and

30. No data were obtained in June for E. coli at Domtar Packaging Ltd., but the river data suggest that levels were low in this time period. Thus the situation in 1987 appears to be similar to that in 1984 (MOE Southeastern Region unpublished data mentioned in Section 1.0) - i.e. Domtar is a source of intermittent sanitary discharges. The magnitude of this input during the wet period was apparently larger than any additional storm sewer inputs which may have conceivably occurred from the downtown area. The 1984 studies suggested that the log bark wash waste stream was the source of sanitary contamination. The continuing presence of high E. coli levels indicates the need for further study of this problem and corrective measures such as disinfection and/or diversion of this waste stream to the Trenton STP for treatment.

4.1.3 Klebsiella pneumoniae

Data are shown in Figures 7 and 10 for the Bay and Figures 15 and 18 for the Trent River. During June, the highest Klebsiella levels were found from the Domtar discharge downstream to the Dixon Drive transect, and also in a zone of the Bay just outside of the river mouth. Klebsiella levels above 100 organisms/100 mL extended southward towards the west end of the bay past the southernmost stations sampled at this time; however levels dropped rapidly to non-detectable levels in the east end of the study area, including the Bain Park beach area. In addition, high Klebsiella levels (500-2600/100 mL) were found upstream of the Domtar outfall, suggesting an input from Trent Valley Paperboard or other location north of the city. Because of these observations, sampling was extended both northward and southward in August as already described in Section 3.0.

As mentioned in Section 3.0, the analytical load during August was split between the Ministry laboratory and Ryan Analytical because of insufficient capacity at the Ministry laboratory to analyze the number of samples expected. On August 11 and 12, one

sample was collected at each location for analysis at the Ministry laboratory, and a second (replicate) sample was collected for analysis at Ryan Analytical. In addition, two extra replicates were taken daily at 4 randomly chosen source or river stations and 4 randomly chosen Bay stations, one for each laboratory. The results were compared by matched-pair t-tests using all available data for the two days, and by comparing the relative variation of the within-lab and between-lab replicates for each parameter, using data from the replicated locations mentioned above. All data were log-transformed before analysis. Analyses were done by IBM-PC using the Statgraphics statistical package.

Tables 3 and 4 show the results of these analyses. While the data show no significant difference between the two laboratories for fecal coliforms and E. coli, the Ryan lab produced results which were highly significantly lower ($p < 0.001$) for Klebsiella, relative to the Ministry lab. Differences were most profound in the Trent River. Limited sample numbers and large between-day and between-location variance resulted in no significant difference being observed for the source locations, despite the fact that the two-day geometric mean for MOE Klebsiella data was about 7 times as high as that for Ryan Klebsiella data.

Therefore, all results from both laboratories have been used together for fecal coliforms and E. coli, but only the Ministry laboratory results have been used for Klebsiella pneumonia. Consequently, no wet weather Klebsiella data are available, as these samples were all analyzed by Ryan Analytical.

Dry weather Klebsiella data (Figure 10) show the existence of a large plume area in the Bay offshore of the Trent River mouth, extending southward up to 2 km on August 11 and 12. A somewhat patchy distribution of the highest Klebsiella levels (as also seen in June) again suggests that the Domtar loadings are highly time-variant, as was suggested by the 1984 data. This is suggested also by the grab sample results at the effluent pipe

(Figure 18) which showed a variation from 8.1 x 10^7 organisms/ 100 mL on August 11 to below 10,000 organisms/100 mL on August 13. At the same time, in-plume levels varied from 1.1 x 10^5 organisms/100 mL on August 11 to 590 organisms/100 mL on August 13. Because of this time variation, and because many river transect values recorded "greater than" values (Figure 18), it is hard to quantify the Klebsiella levels and impact on the Trent River. Complete quantification would require a time-series sampling study at the plant discharge and at several points both up and downstream.

Upstream Klebsiella data show the existence of further inputs, which again could not be quantified due to the high variability and existence of "greater than" results. Although the Trent Valley Paperboard plant is the likely source of most of these bacteria, levels of 210-1830 Klebsiella/100 mL were observed at dam #4 upstream of the plant (stations 112, 113, 114, Figure 18). The source of these Klebsiella is unknown.

The human health significance of Klebsiella has been a topic of much discussion (Duncan, 1988, and references cited therein). At one time it was believed that Klebsiella could be a serious pathogen, when present in recreation waters. However, epidemiological studies have indicated that Klebsiella infections only occur in hospitalized patients already debilitated by other illnesses. In particular, studies of pulp and paper mill workers occupationally exposed to high Klebsiella levels suggest that only a few percent become carriers of Klebsiella, and that even these individuals seldom if ever develop symptoms. Duncan (1987) also reviewed studies of Klebsiella in recreational surface waters and showed no evidence of disease outbreaks related to this organism. Hence, fecal coliform counts resulting solely or mainly due to the presence of Klebsiella are misleading as indicators of potential health hazards.

The presence of Klebsiella can interfere in the determination of fecal coliforms in the usual MTEC fecal coliform test. However, only a small but variable proportion (1 in 10 to several hundred) of the Klebsiella produce a positive fecal coliform test (estimated as the ratio of Klebsiella over the FC-EC excess). This is because the Klebsiella do not have the same ability to utilize the MTEC media as other fecal coliforms; therefore only a variable portion of the Klebsiella are counted. In addition, the bacterial growth rates are temperature- dependent: the optimum growth rate of E. coli occurs at 45°C (the incubation temperatures for the fecal coliform test), while the optimum for Klebsiella is 35°C. As the Klebsiella do not appear to be associated with pathogens (see above), these facts support the use of E. coli as a perferred health indicator.

Routine testing for E. coli in the future should be facilitated by a new one-step procedure involving a test medium containing indoxyl-β-D-glucuronide (Ley et al, 1988). This reagent is broken down by E. coli, producing a distinctive blue color. Other fecal coliforms, such as Klebsiella, Enterobacter and Citrobacter do not produce this reaction. The procedure is also faster than the current multiple-step procedure used by the Ministry.

4.2 Deseronto

In June, two days' worth of data representing dry weather conditions were obtained; in addition, the Centennial Park Beach locations were sampled for three dry weather days in August (during the Picton dry weather survey). Fecal coliform and E. coli data for these periods are summarized in Figures 21 and 22, respectively. In no cases did any open water location exceed 100 FC/100 mL or 23 E. coli/100 mL during June; the highest open water two-sample geometric mean results on June 24 were

16 FC/100 mL and 16 EC/100 mL at Station 434 (entrance to Deseronto marina), and on June 25, 13 FC/100 mL and 13 EC/100 mL at Station 301 (mouth of Napanee River). The highest two-sample geometric mean at Centennial Beach in June was 34 FC/100 mL and 34 EC/100 mL on the east side on June 24. This was the only instance in June that the proposed IJC guideline of 23 E. coli/ 100 mL was exceeded; due to the generally good dry weather bacteriological quality in Deseronto, the August dry weather survey was cancelled and replaced by sampling at the beach locations only during the Picton dry weather survey.

The August beach data are also shown in Figures 21 and 22. While all fecal coliform levels were below 100/100 mL, the location to the east of the pier did show values slightly higher than those in June; two of the three days the E. coli levels were above the proposed IJC Guidelines. The maximum two-sample geometric means were 88 FC/100 mL on August 16 and 66 E. coli/100 mL on August 17. The Health Unit sampled this beach on four dates in 1987. While three of 20 individual samples exceeded 100 FC/ 100 mL, the maximum daily 5-sample geometric mean was 84 FC/ 100 mL and the overall geometric mean was 37 FC/100 mL. No relation between increased FC levels and rainfall was found.

Three days' worth of wet weather data were obtained in early September. While only a trace of rainfall was recorded at the Kingston and Trenton weather stations, a localized rainfall event of unknown magnitude was observed in the Napanee-Deseronto area on September 2. Data for fecal coliforms and E. coli are summarized in Figures 23 and 24. The rainfall on September 2 resulted in extremely high fecal coliform counts (1.6×10^7 FC/100 mL) at the Deseronto STP; however, the duration of the high bacterial input must have been short as no impact was found in the receiving water. The only impact in the receiving water originated from the Napanee River and moved downstream into the open water away from shore and well away from the Centennial Park beach area, where counts remained low at all times.

The results obtained in 1987 at Deseronto confirm the observations of 1981 (Griffiths, 1984) that no clearly established bacteriological degradation from local sources was evident. As expected, no impact was found in the area close to the inoperative Arctic Gardens plant. Some wet weather impact originating from upstream in the Napanee River was indicated by this study. Canviro (1987) indicated that two pumping stations in Napanee have overflows to the river, but that discharges from these or combined sewer overflows seldom if ever occur. However, they did indicate that infiltration and inflow to the sewage system is known to exist. Based on the Canviro report, some remediation measures are required at the Napanee STP as this STP is not in compliance with total phosphorus, BOD and suspended solids requirements. At any rate, no conclusion can be drawn as to the exact source of the upstream bacterial input without collecting additional samples in the effluent and river at various points.

4.3 Picton

Dry weather results (June 30, July 1, August 16-18) are summarized in Figures 25 and 26 for fecal coliforms and *E. coli*, respectively. The zone in the bay where the two-sample geometric mean fecal coliform level exceeded 100 organisms/100 mL was confined to the area closest to the south end of the bay (one or two stations within 100 - 200 m of Marsh Creek) on all days. The *E. coli* level exceeded the suggested IJC guideline of 23/100 mL in the same area plus a variable zone extending from the vicinity of the Prince Edward Yacht Club (Station 319) to Chimney Point (near the Picton WTP intake; Station 316). Bacterial levels in the lower reaches of Picton Marsh Creek are highly variable (see also below) and do not appear to be related to occurrences of high values in the south end of the bay. In addition dry weather bacterial levels at the Picton STP were always low, with daily geometric means ranging from 11 to 94 FC/100 mL. Therefore, no obvious source of dry weather bacterial contamination in Picton Bay is evident. The situation is similar to that observed during

dry weather at several points along the Kingston waterfront in 1985 (Poulton, 1987); as in Kingston, it is an area of extensive recreational boating which could be the source of sporadic inputs. The extent of contamination is not likely enough to be of great concern. Possible inputs to the WTP intake should be ameliorated by the normal filtration and chlorination processes.

The variable nature of the bacterial levels was further illustrated by the two sampling runs on August 18 which were done several hours apart. Table 5 illustrates results from the mouth of Picton Marsh Creek and the south end of Picton Bay. Increases by factors of up to five in the fecal coliform levels occurred at the mouth of Picton Marsh Creek, (station 15 - 84) while decreases occurred at the same time at the station 322-323-324 transect. This shows further evidence of the sporadic nature, both in time and space, of bacterial contamination.

In Picton Marsh Creek, higher bacterial levels were found upstream at Station 15-88 (117 and 95 FC/100 mL) during the first survey interval, than farther downstream. For this reason, a second upstream station (15-89) was established for the August survey. This point yielded consistently over 1000 FC/100 mL; levels at the Picton Heights STP were also very high (up to 2.9×10^4 FC/100 mL), thus suggesting this STP as the source of upstream contamination. If the suggested closing of this STP and diversion of its influent to the Picton STP occurs (Canviro, 1987), the problem should be rectified. Otherwise, the effluent chlorination procedures should be re-evaluated for proper disinfection efficiency.

Wet weather results, representing a total of 15.6 mm rainfall are shown in Figures 27 and 28 for fecal coliforms and E. coli, respectively. Relative to the dry weather situation, an increased zone of impact in the bay is noted, both for fecal coliforms at the south end to about 300 m from the mouth of Marsh

Creek, and E. coli >23/100 mL, which extended north to the area of Prince Edward Marina (about 600 m from Marsh Creek) on all three days, and once to the vicinity of the Picton WTP intake (about 1 km from Marsh Creek). Bacterial levels at the mouth of Picton Marsh Creek (Station 15-84) were also considerably elevated relative to dry weather conditions on the first two survey days (4500 and 1180 FC/100 mL), but had returned to levels similar to those observed under dry weather conditions (187 FC/100 mL) on the third day. Immediately after the rainfall, high bacterial levels were found in the Picton STP effluent (1360 FC/100 mL) and the large storm sewer draining to Marsh Creek just upstream (2300 FC/100 mL). These counts had decreased by the next day, but the impact was still observed at the creek mouth that day and in the bay at least up to the next day (September 2; trace of rain but 48 hours after the major rainfall). Further upstream, bacterial levels were higher at Station 15-88 in the wet weather period, but 15-89 and the Picton Heights STP had bacterial levels which were similar to those found during the August dry weather survey. It should be noted that only on the one day mentioned above was the bacterial level high at the Picton STP effluent.

The maximum wet weather zone of FC >100/100 mL (August 31 - September 1; Figure 28) is smaller than those found in 1981 by Griffiths (1984) on four different occasions following rainfalls of 5 to 36 mm. As in 1987, levels in the Picton STP effluent had been found to be generally low and the contamination had been attributed to storm and combined sewers. Apparently the sewer separation program has helped to reduce overflow occurrences; however the 1987 data do indicate that some overflows (e.g. the culvert on Marsh Creek at 15-87) are still occurring. Canviro (1987) documented extensive inflow/infiltration and bypassing problems during wet weather at the Picton Heights sewage collection system. This is bound to have some impact on the bacterial levels in Marsh Creek (Stations 15-89, 88, 86, 84) and consequently the loadings to the south end of the bay. Some

infiltration within the Picton sewage collection system (Canviro, 1987) may also be contributing. A pumping station at Hill Street, southwest of the Picton WTP has an overflow bypass to the Bay (near Station 333); however local records do not indicate any bypassing here and the bacterial data gathered in this survey appear to support this fact.

In conclusion, although the wet weather data indicate a reduced impact since 1981, a significant wet weather input still exists in the upper bay and Marsh Creek. Further attention needs to be paid to infiltration and bypassing at Picton Heights and overflows within the town of Picton itself.

4.4 North Port

Bacteriologial samples were collected at North Port on the same days as Picton samples. No problems were found at any time, with the maximum daily 2-sample geometric mean being 40 FC/100 mL and the overall geometric mean being 7 FC/100 mL. This location was also sampled on five dates in 1987 by the Health Unit. They likewise found no problem, with no samples exceeding 100 FC/100 mL and an overall geometric mean of 17 FC/100 mL.

5.0 ACKNOWLEDGEMENTS

The author gratefully acknowledges the assistance of the following staff at MOE Southeastern Region for their assistance; Mr. M. German, Mr. G. Owen, Dr. A. Ley, Mr. F. Stride, plus Toronto laboratory and field support staff. Thanks are extended to the Great Lakes survey crews under the direction of Mr. E. Law, who collected the samples for this study, and to staff at Domtar Packaging Ltd. and the various area sewage treatment plants who permitted access to their effluent discharge locations. The assistance of the Hastings and Prince Edward Counties Health Unit, who provided important beach data, is gratefully acknowledged. Thanks are also extended to Ms. M. Griffiths of the Great Lakes Section, for her advice during the planning and execution of this survey, and for her helpful comments.

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TABLE 1

FECAL COLIFORM LEVELS (#/100 mL) AT BAY OF QUINTE BEACHES
(HEALTH UNIT SAMPLING), 1982-87

	1982		1984		1985		1986		1987	
Location	Gm	%>100	Gm	%>100	Gm	%>100	Gm	%>100	Gm	%>100
Trenton (Trent River)	30	16	-	-	-	-	73	33	-	-
Trenton (Fraser St.)	65	23	-	-	-	-	-	-	-	-
Trenton (Bain Park)	-	-	65	50	12	0	25	17	34	23
Frankford (Trailer Park)	-	-	-	-	-	-	250	63	480	92
Belleville (Zwick Is.)	91	46	14	7	19	18	19	0	42	27
(MOE samples)	-	-	25	0	-	-	-	-	-	-
Belleville (Riverside)	-	-	127	45	88	39	210	80	325	97
(MOE samples)	-	-	225	86	125	45	-	-	-	-
Belleville (Government Dock)	58	35	-	-	-	-	-	-	-	-
Deseronto (Centennial Park)	58	28	-	-	-	-	38	0	37	15

NOTE: (MOE samples indicates data obtained by Ministry of Environment, Great Lakes Section (Poulton, 1986).

All other data from Hastings and Prince Edward Counties Health Unit.

No bacteriological samples were collected during 1983.

TABLE 2
SURVEY DATES
BAY OF QUINTE RAP BACTERIOLOGICAL SURVEY, 1987

LOCATION	SURVEY DATE	RAINFALL (mm) 24 HOURS PREVIOUS	LABORATORY USED (M = MINISTRY, R = RYAN)
Trenton	June 22	2.8	M
	June 23	nil	M
	August 11	nil	M, R
	August 12	nil	M, R
	August 13	nil	M
	August 29	10.5 (5.6 mm on Aug. 28)	R
	August 30	nil	R
	August 31	5.6	R
Deseronto	June 24	nil	M
	June 25	nil	M
	Septemter 2	trace* (1.0 mm on Sept. 1)	R
	September 3	nil	M
	September 4	nil	R
Picton and North Port	June 30	trace (1.8 mm on June 29)	M
	July 1	nil	M
	August 16	nil	M
	August 17	nil	M
	August 18	nil	M
	August 31	14.6	M, R
	September 1	1.0	M
	September 2	trace	M

NOTE: Trenton rainfall data from CFB Trenton.
Deseronto and Picton rainfall data from Kingston Airport
No rainfall occurred on the second previous 24 hours before each survey date, unless indicated in parentheses or on line above.

NOTE*: Although local data were not available, field crew observations suggested a larger amount of rainfall.

TABLE 3
MATCHED PAIR T-TESTS OF MOE VS. RYAN LAB DATA
TRENTON, AUGUST 11-12, 1987

LOCATION	PARAMETER	NO. OF OBSERVATIONS	MOE GEOMETRIC MEAN	RYAN GEOMETRIC MEAN	T VALUE	PROB.
Bay	Fecal coliforms	99	8	9	-0.55	NS
	E. coli	99	6	6	-1.12	NS
	Klebsiella	97	138	60	4.83	<0.001
River	Fecal coliforms	53	94	95	-0.19	NS
	E. coli	53	40	49	-1.78	NS
	Klebsiella	49	5950	228	10.31	<0.001
Sources	Fecal coliforms	7	630	360	1.46	NS
	E. coli	7	500	280	1.10	NS
	Klebsiella	7	2050	280	0.65	NS

NOTE: Geometric means are in organisms/100 mL
"Sources" includes Trenton STP, Trenton CFB STP and Domtar Packaging Ltd.
NS = not significant

TABLE 4
ANALYSIS OF VARIANCE, REPLICATED DATA
(Comparison of MOE and Ryan Laboratories)

(a) Fecal Coliforms

ANALYSIS OF VARIANCE FOR LOG (fecal coliforms)					
Source of Variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Station	114.77529	1	114.77529	26.866	.0000
Lab	.1627647	1	.1627647	.038	.8480
RESIDUAL	243.51260	57	4.2721509		
TOTAL (Corr.)	358.45066	59			

(b) E. coli

ANALYSIS OF VARIANCE FOR LOG (E. coli)					
Source of Variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Station	73.175987	1	73.175987	23.511	.0000
lab	5.18745E-004	1	5.18745E-004	.000	.9899
RESIDUAL	177.40521	57	3.1123721		
TOTAL (Corr.)	250.58172	59			

(c) Klebsiella

ANALYSIS OF VARIANCE FOR LOG (Klebsiella)					
Source of Variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Station	174.69027	1	174.69027	64.122	.0000
Lab	63.616343	1	63.616343	23.351	.0000
RESIDUAL	155.28821	57	2.7243545		
TOTAL (Corr.)	393.59482	59			

TABLE 5
SHORT-TIME VARIABILITY OF BACTERIAL RESULTS
PICTON, AUGUST 18, 1987

STATION	RUN 1			RUN 2		
	TIME	FC #/100 mL	EC #/100 mL	TIME	FC #/100 mL	EC #/100 mL
15-84	9:05	92 93	76 73	11:10	580 460	580 460
325	7:53	128 196	52 60	12:22	428 328	220 252
440	7:55	36 8	36 8	12:25	32 60	20 52
441	7:57	88 40	80 8	12:27	156 176	8 8
322	8:06	56 32	48 20	12:34	20 20	16 16
323	8:03	28 12	16 12	12:32	20 8	16 8
324	8:01	92 56	56 48	12:30	28 36	20 20

NOTE: Pairs of numbers represent single sample results for paired replicate samples.

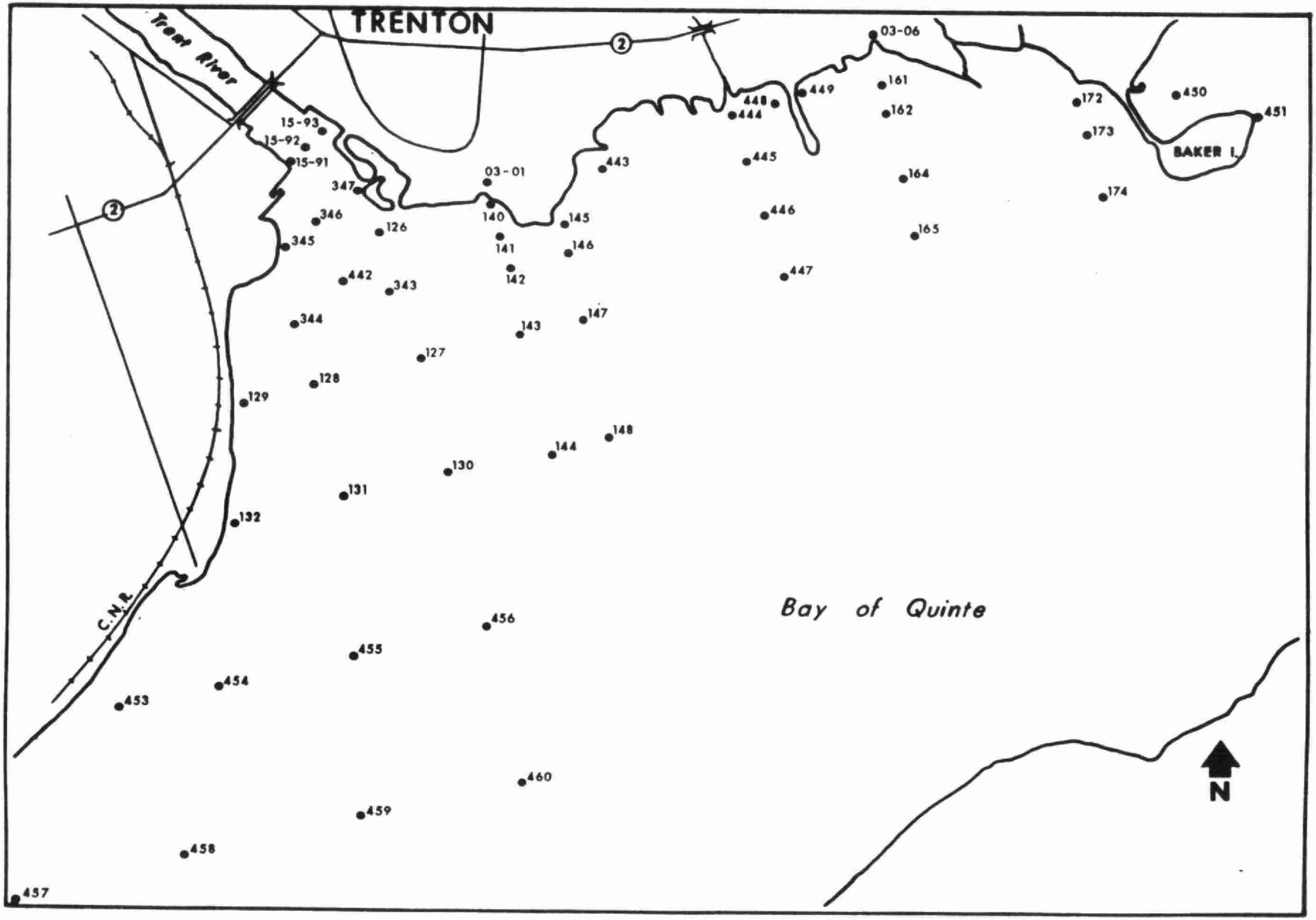

FIGURE 1: Bacteriological sampling stations in the Bay of Quinte at Trenton.

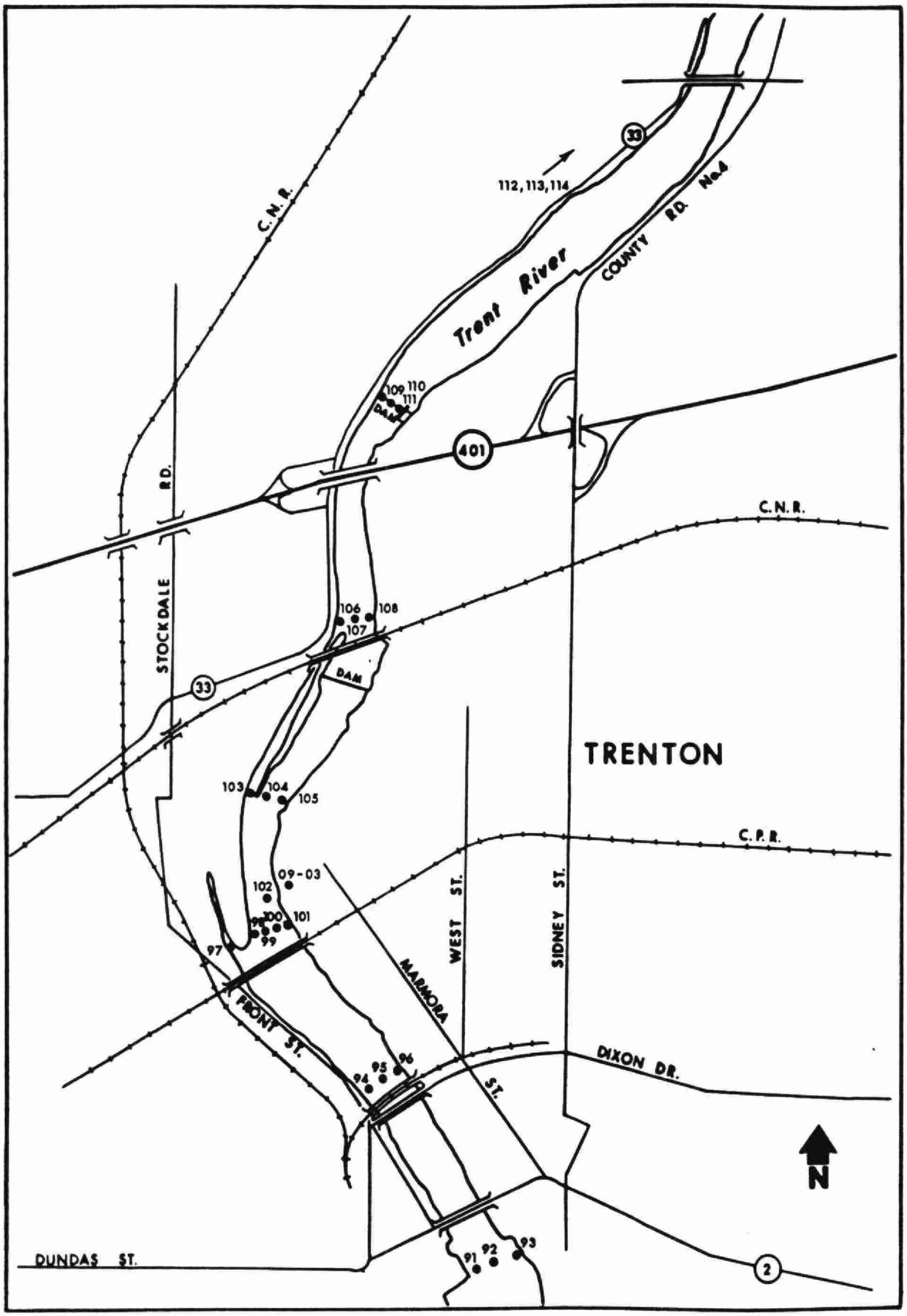

FIGURE 2: Bacteriological sampling stations in the Trent River at Trenton. (station type = 15 unless otherwise indicated)

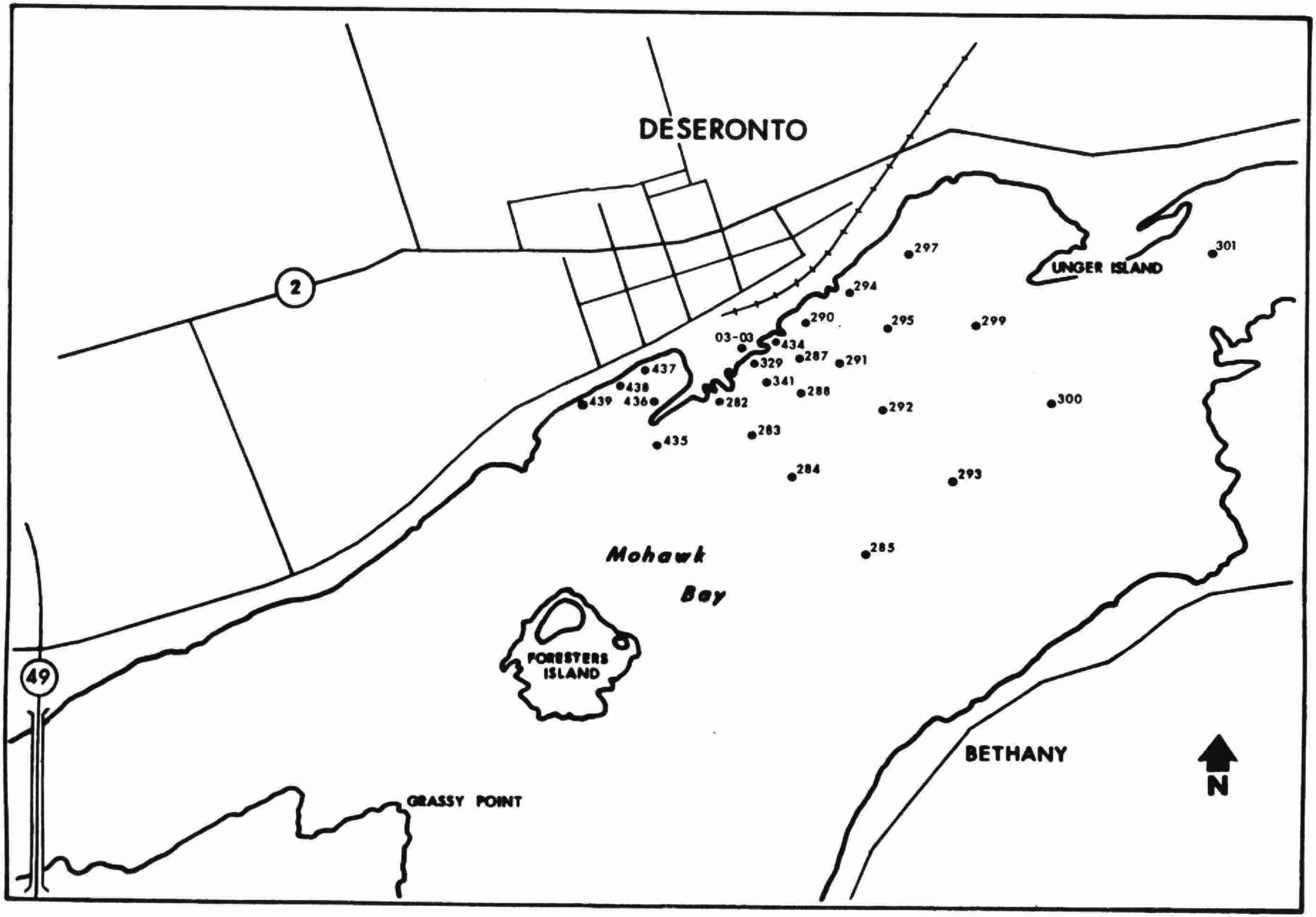

FIGURE 3: Bacteriological sampling stations in the Bay of Quinte at Deseronto.

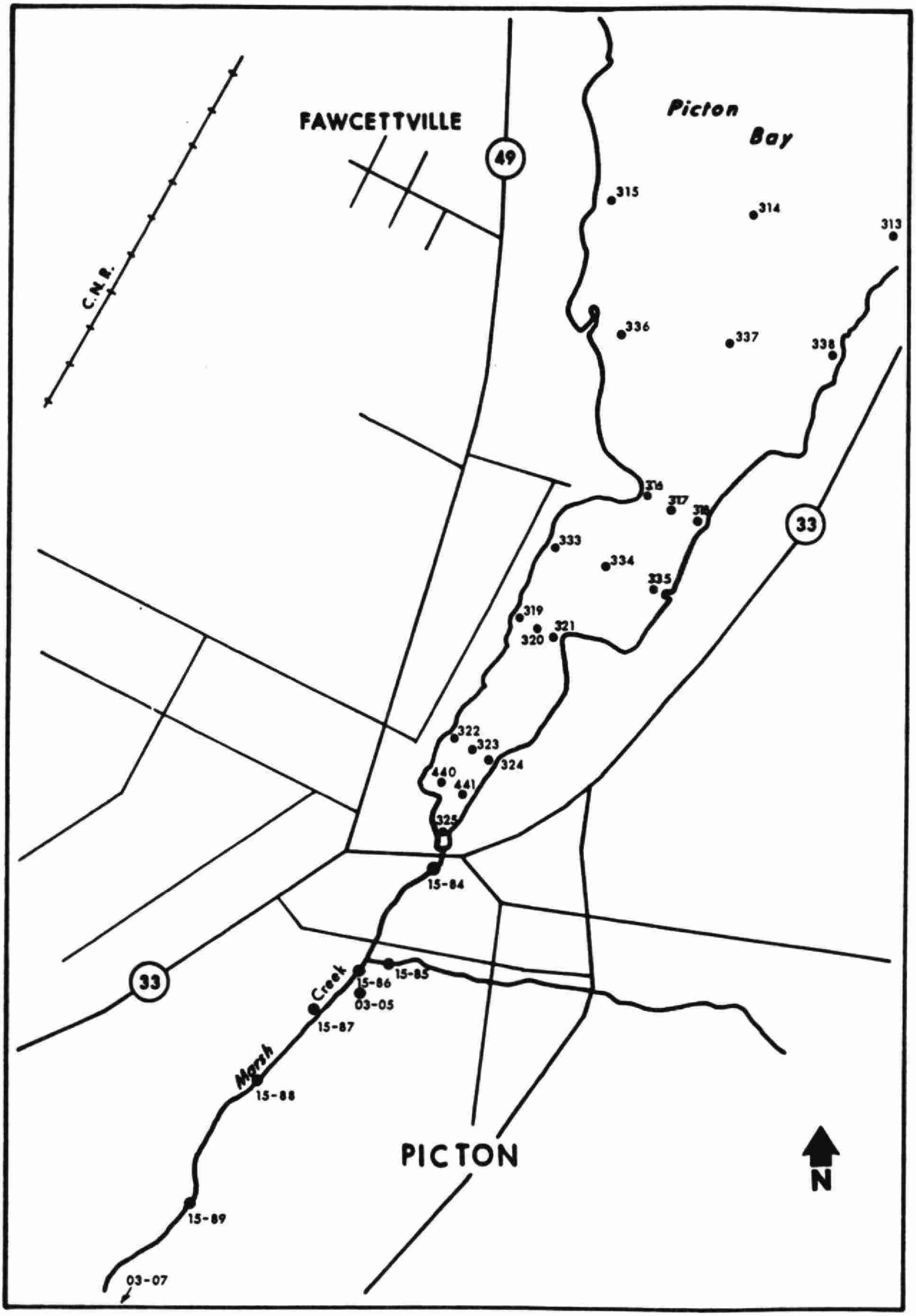

FIGURE 4: Bacteriological sampling stations in the Bay of Quinte and Marsh Creek at Picton.

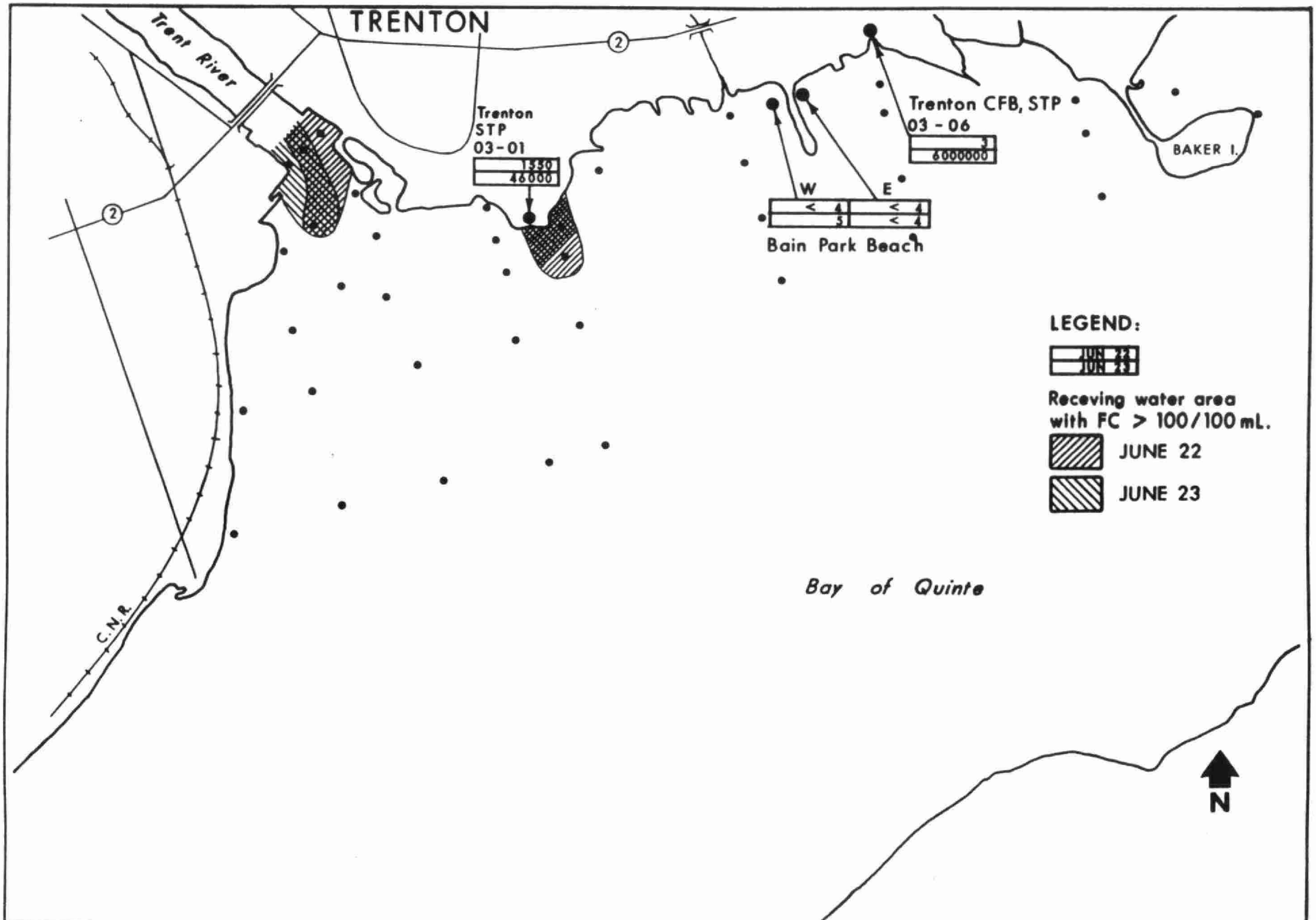

FIGURE 5: Fecal coliform counts (#/100mL) observed in the Bay of Quinte at Trenton, June 1987.

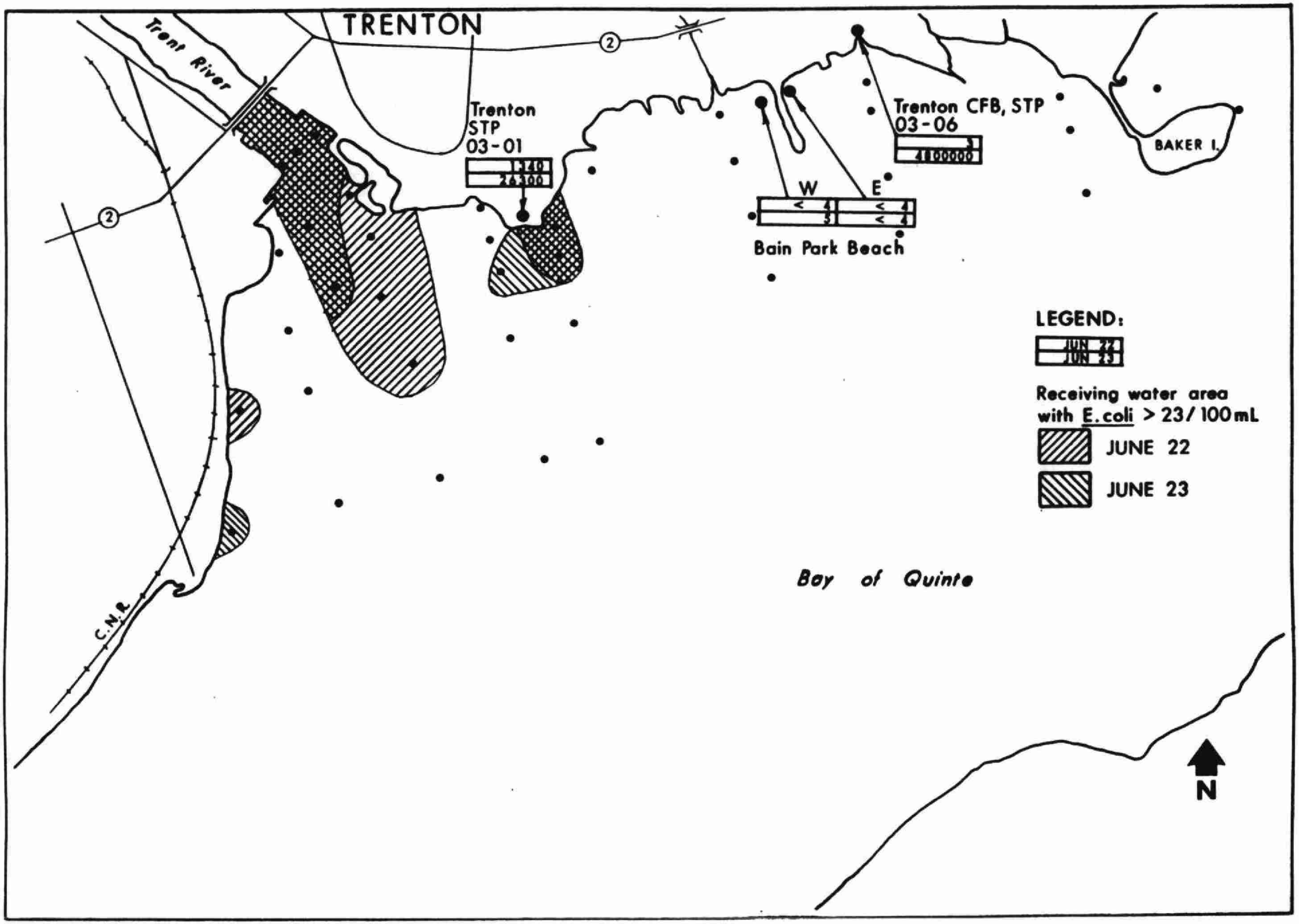

FIGURE 6: E.coli counts (#/100mL) observed in the Bay of Quinte at Trenton, June 1987.

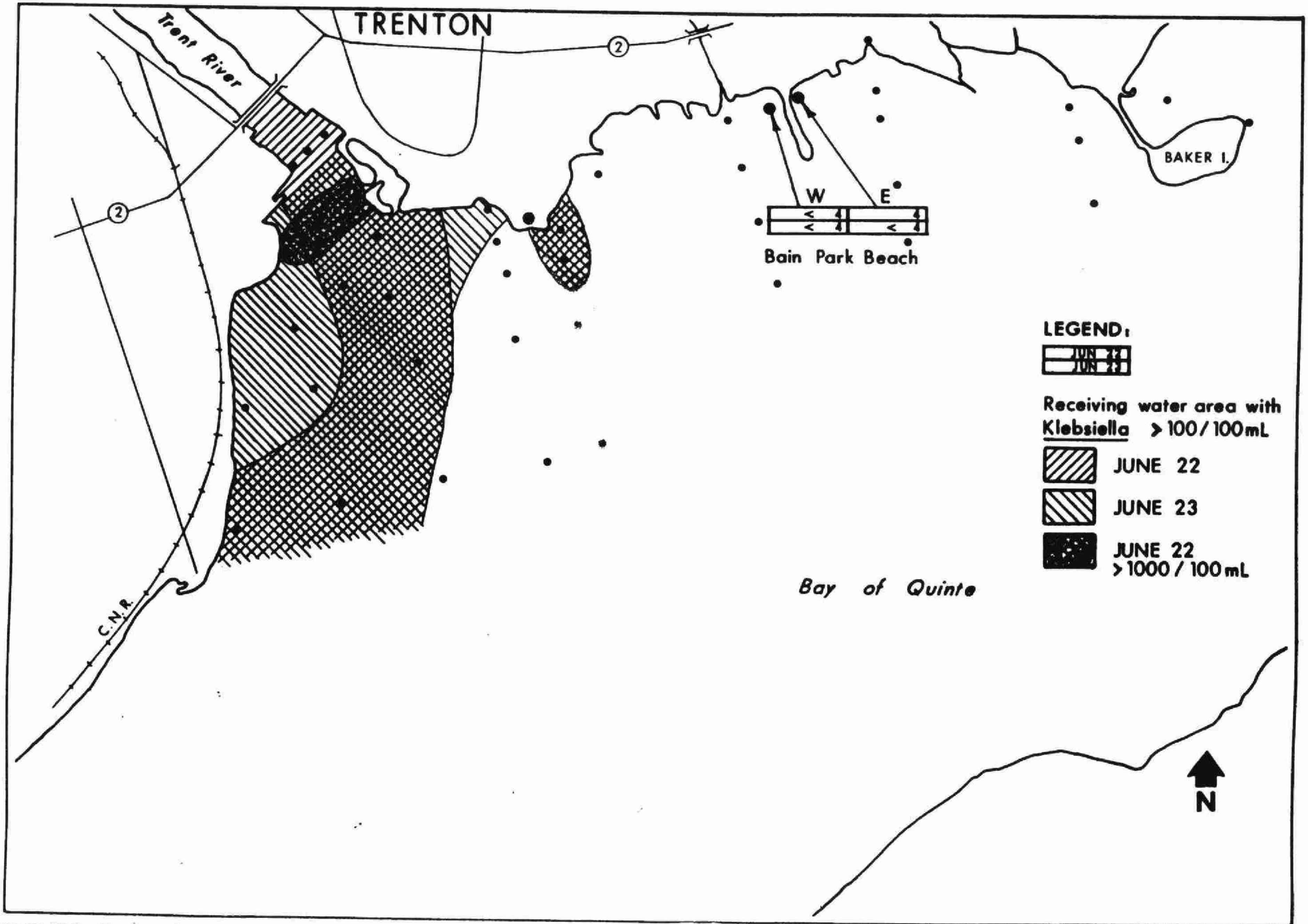

FIGURE 7: Klebsiella pneumonia counts (#/100mL) observed in the Bay of Quinte at Trenton, June 1987.

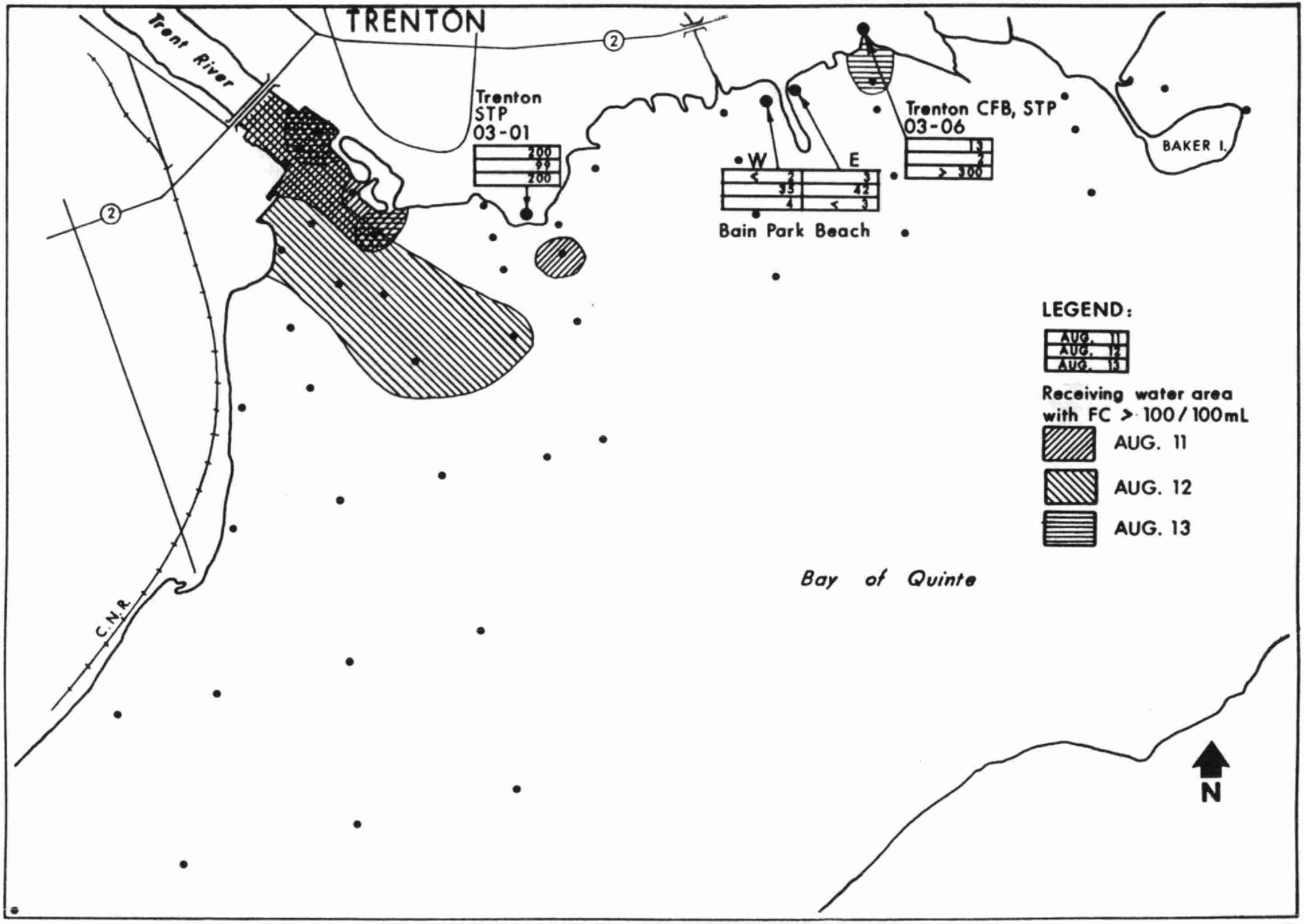

FIGURE 8: Fecal coliform counts (#/100mL) observed in the Bay of Quinte at Trenton during dry weather, August 1987.

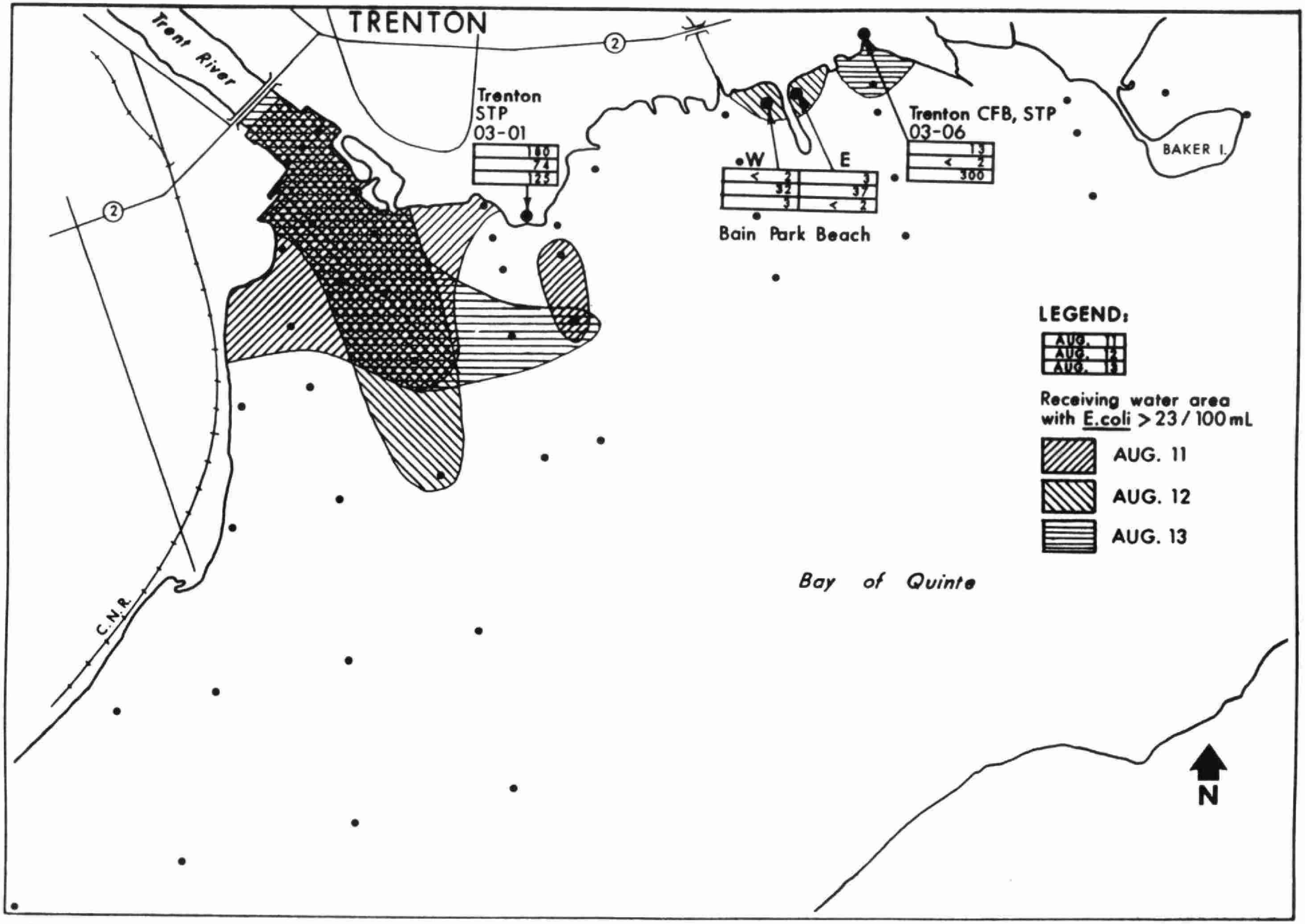

FIGURE 9: E.coli counts (# / 100mL) observed in the Bay of Quinte at Trenton during dry weather, August 1987.

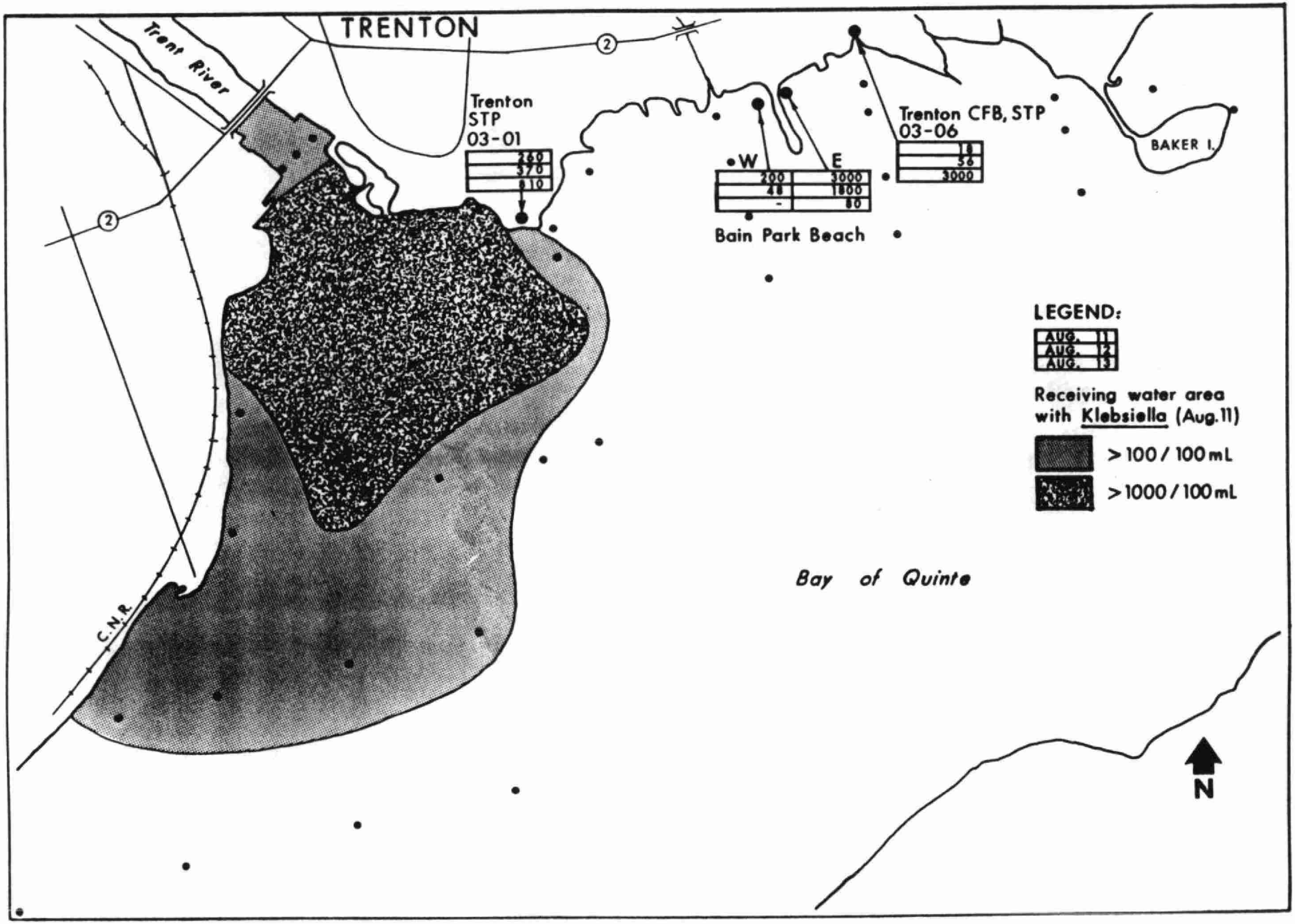

FIGURE 10a: Klebsiella pneumonia counts (#/100mL) observed in the Bay of Quinte at Trenton during dry weather, August 1987

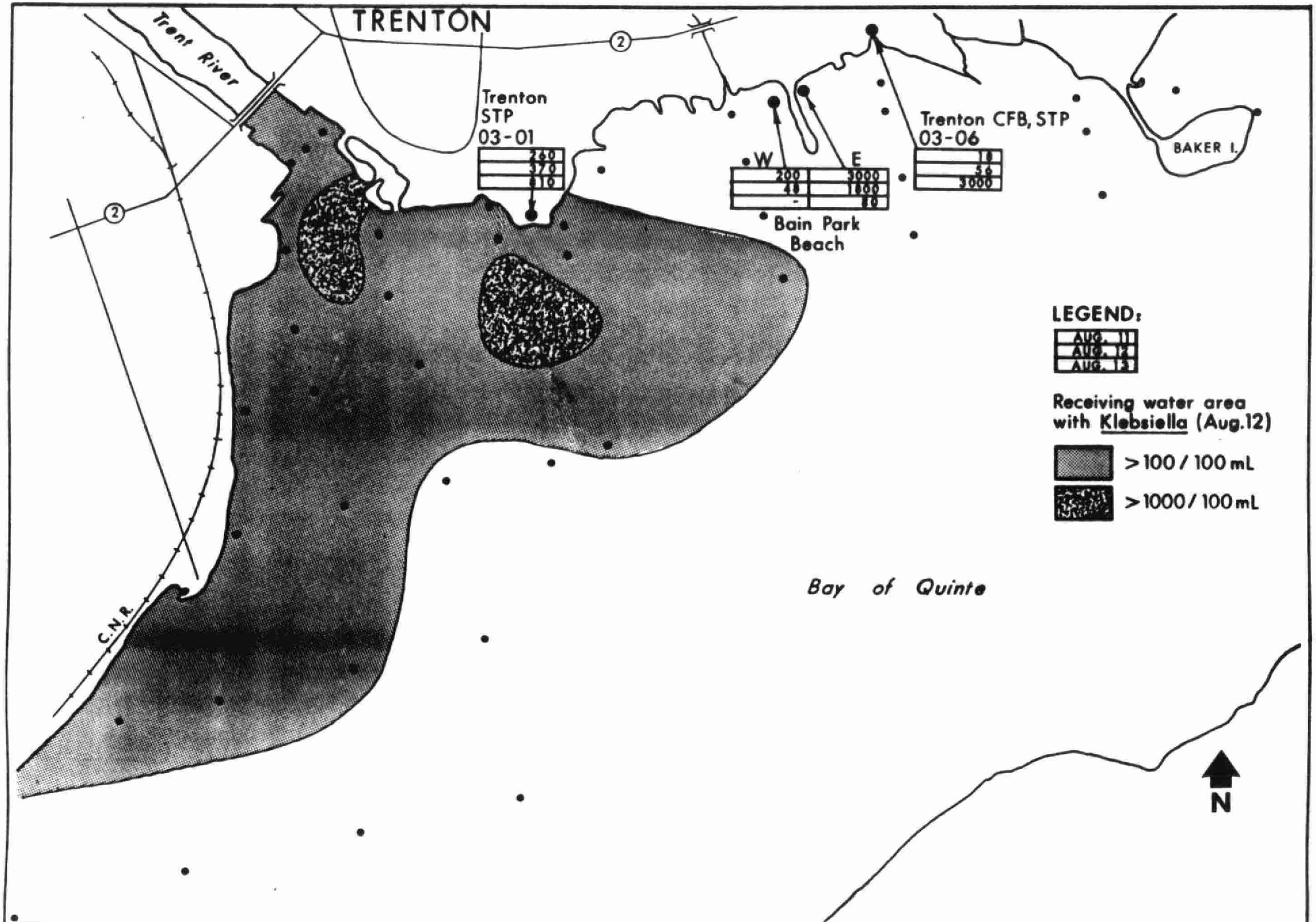

FIGURE 10b: Klebsiella pneumonia counts (#/100mL) observed in the Bay of Quinte at Trenton during

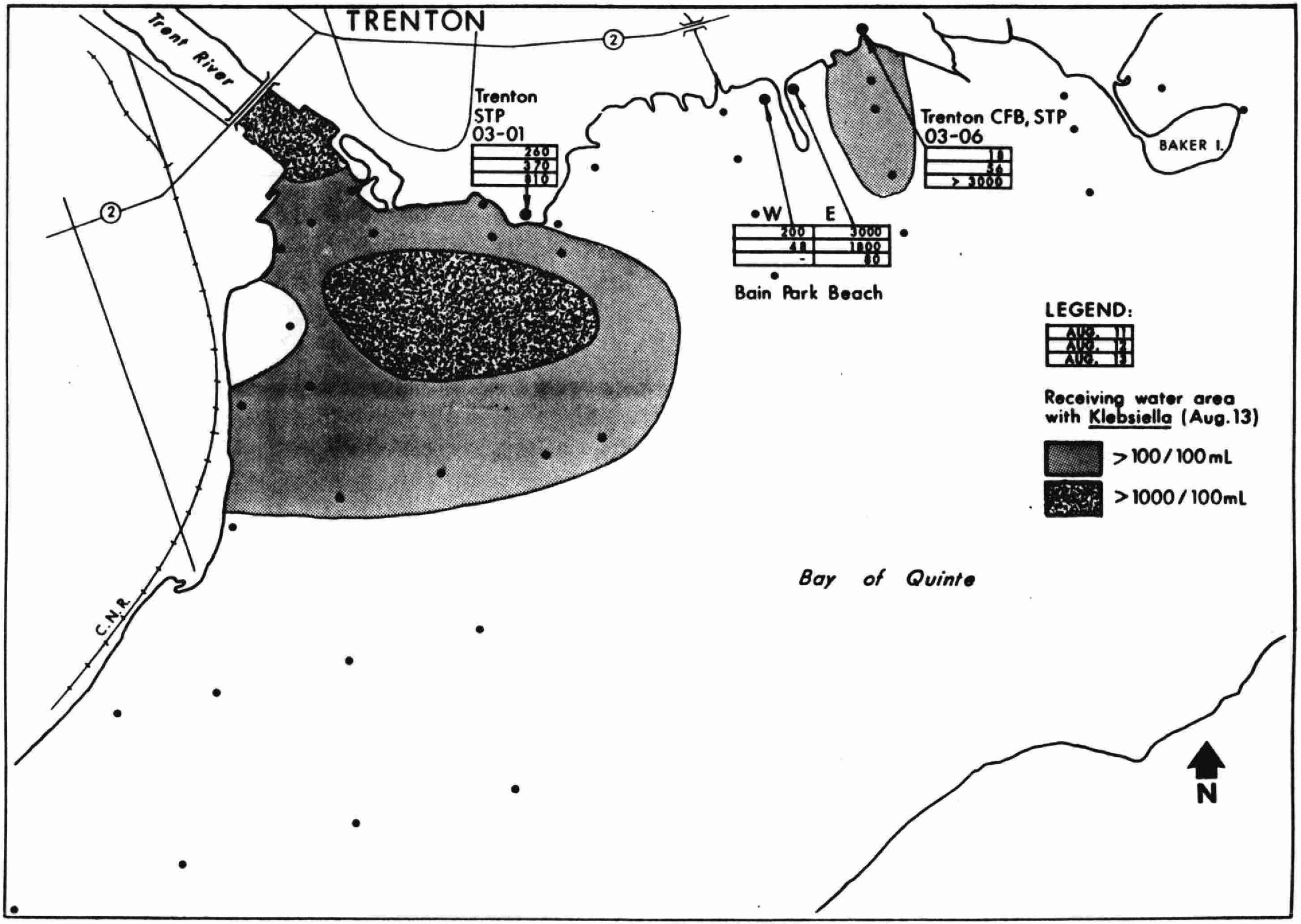

FIGURE 10c: Klebsiella pneumonia counts (#/100 mL) observed in the Bay of Quinte at Trenton during dry weather, August 1987

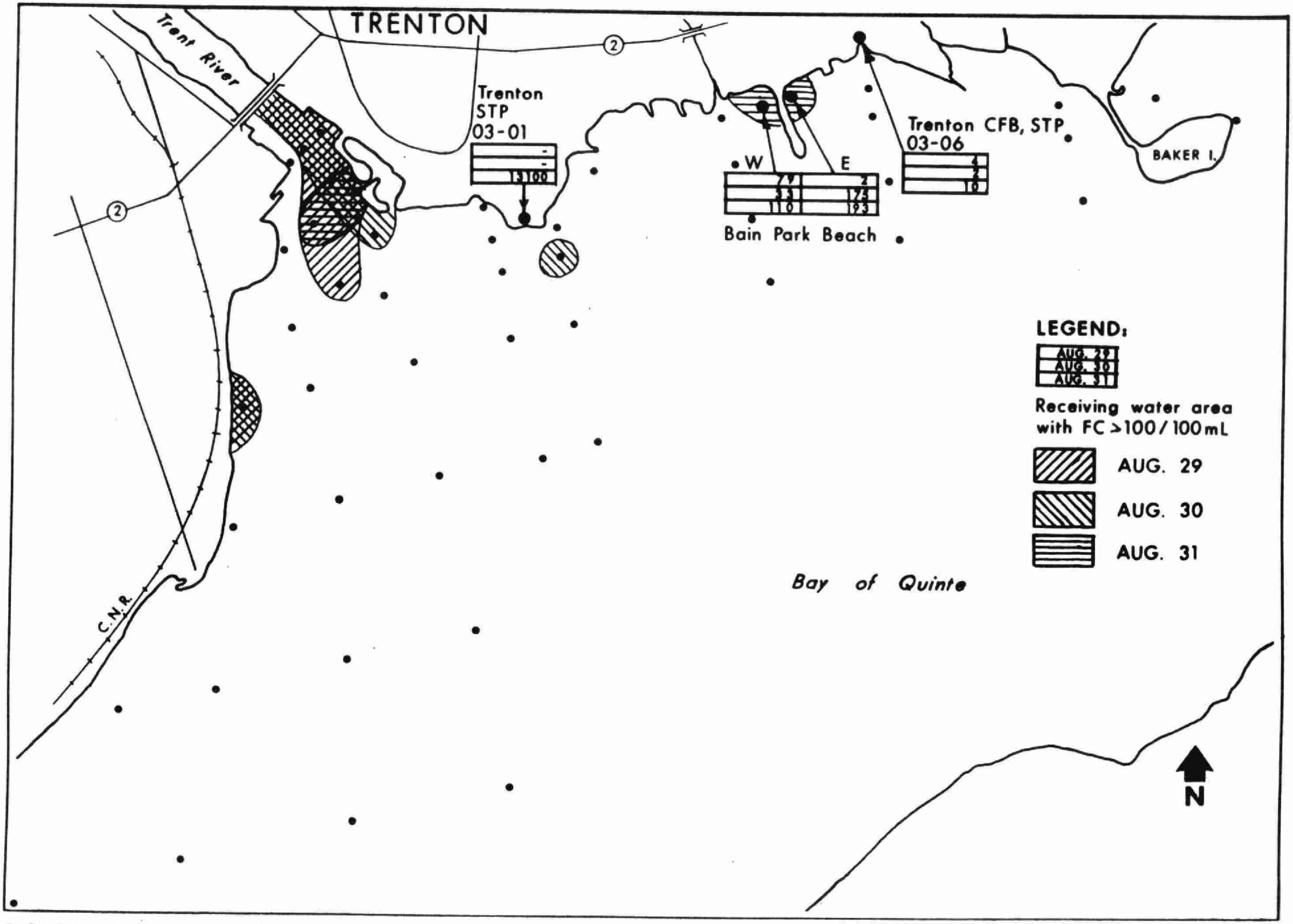

FIGURE 11: Fecal coliform counts (#/100mL) observed in the Bay of Quinte at Trenton during wet weather, August 1987

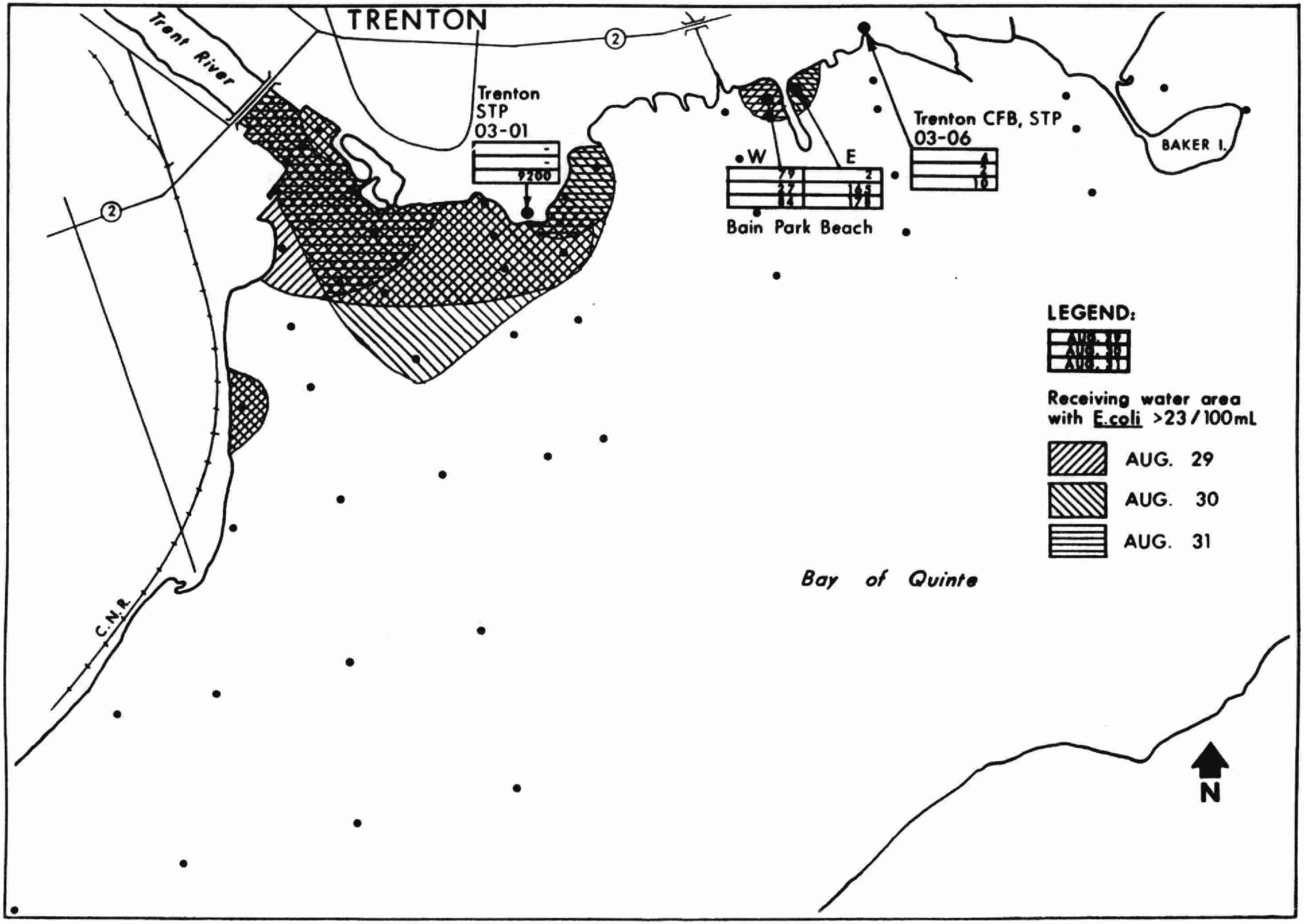

FIGURE 12: E.coli counts (#/100mL) observed in the Bay of Quinte at Trenton during wet weather, August 1987

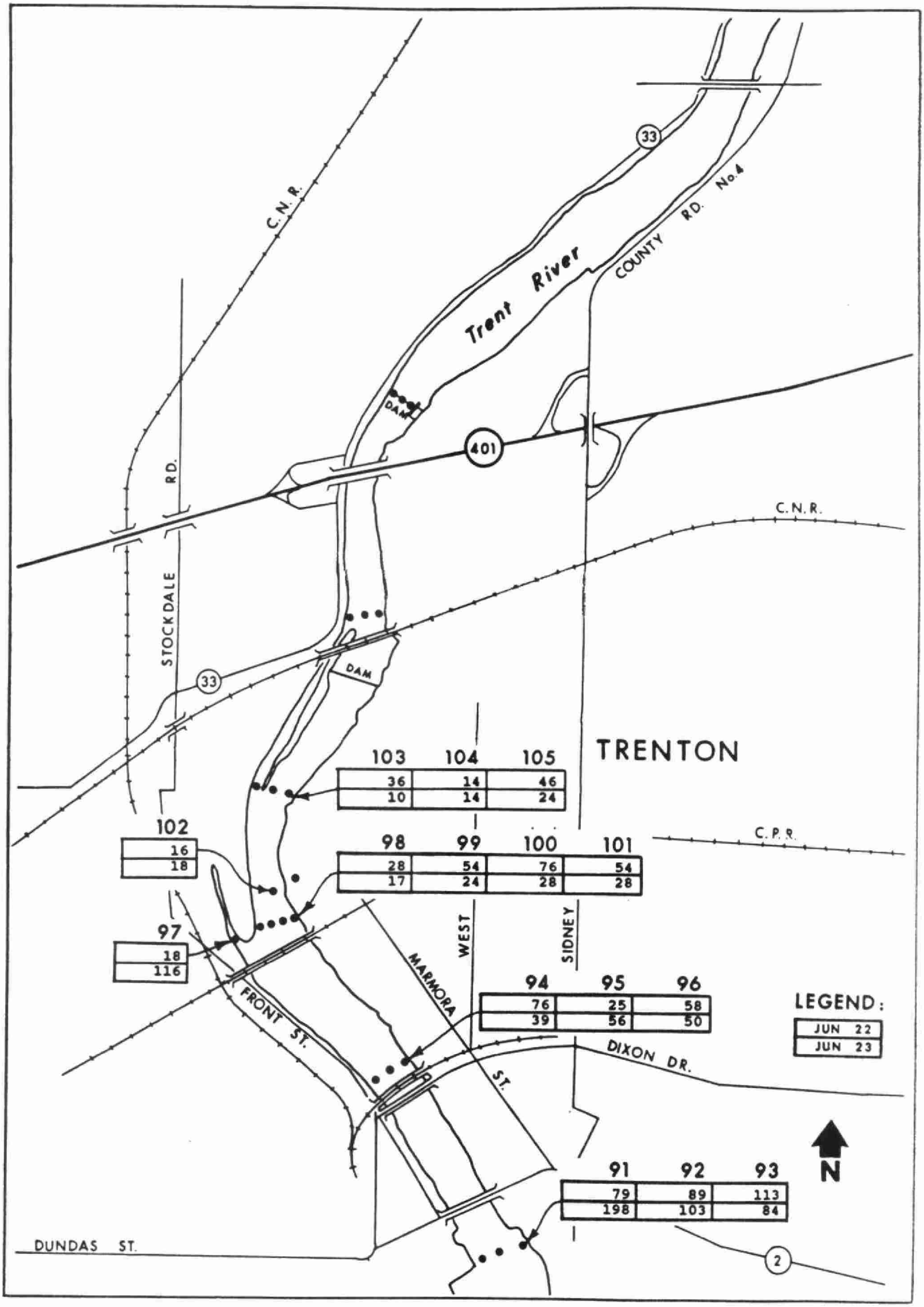

FIGURE 13: Fecal coliform counts (#/100mL) in the Trent River at Trenton, June 1987.

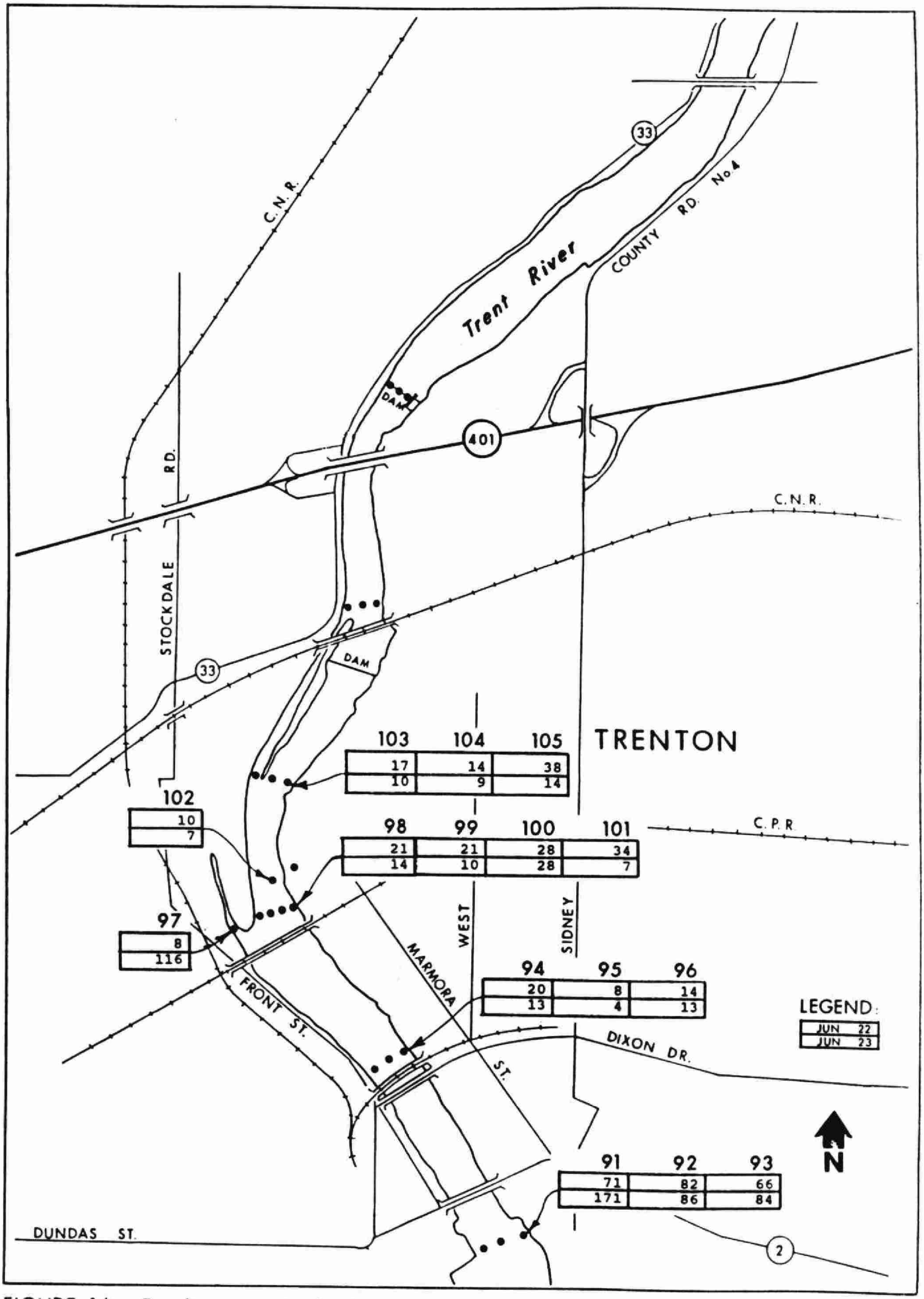

FIGURE 14: E. coli counts in the Trent River at Trenton, June 1987.

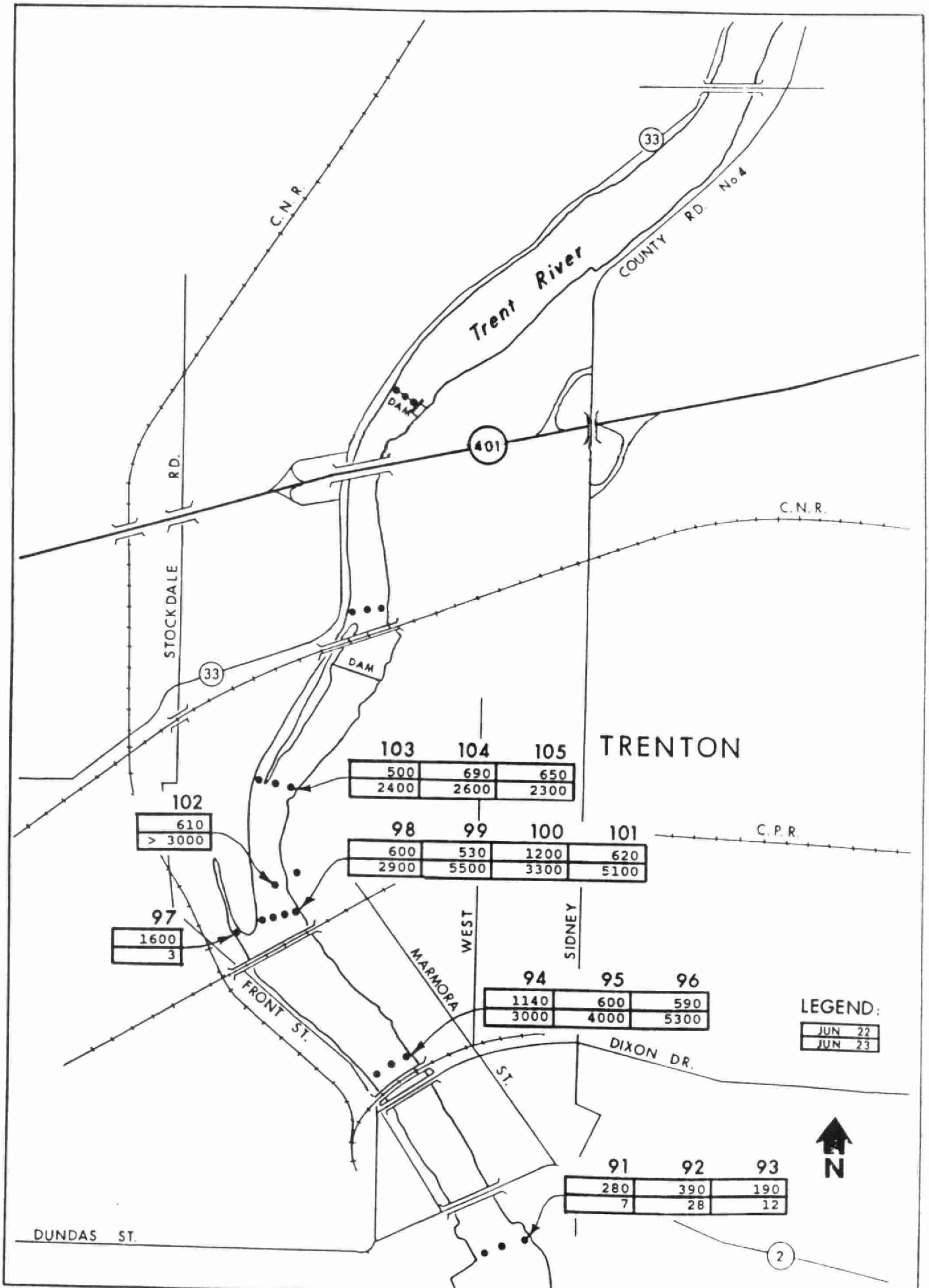

FIGURE 15: Klebsiella pneumonia counts in the Trent River at Trenton, June 1987.

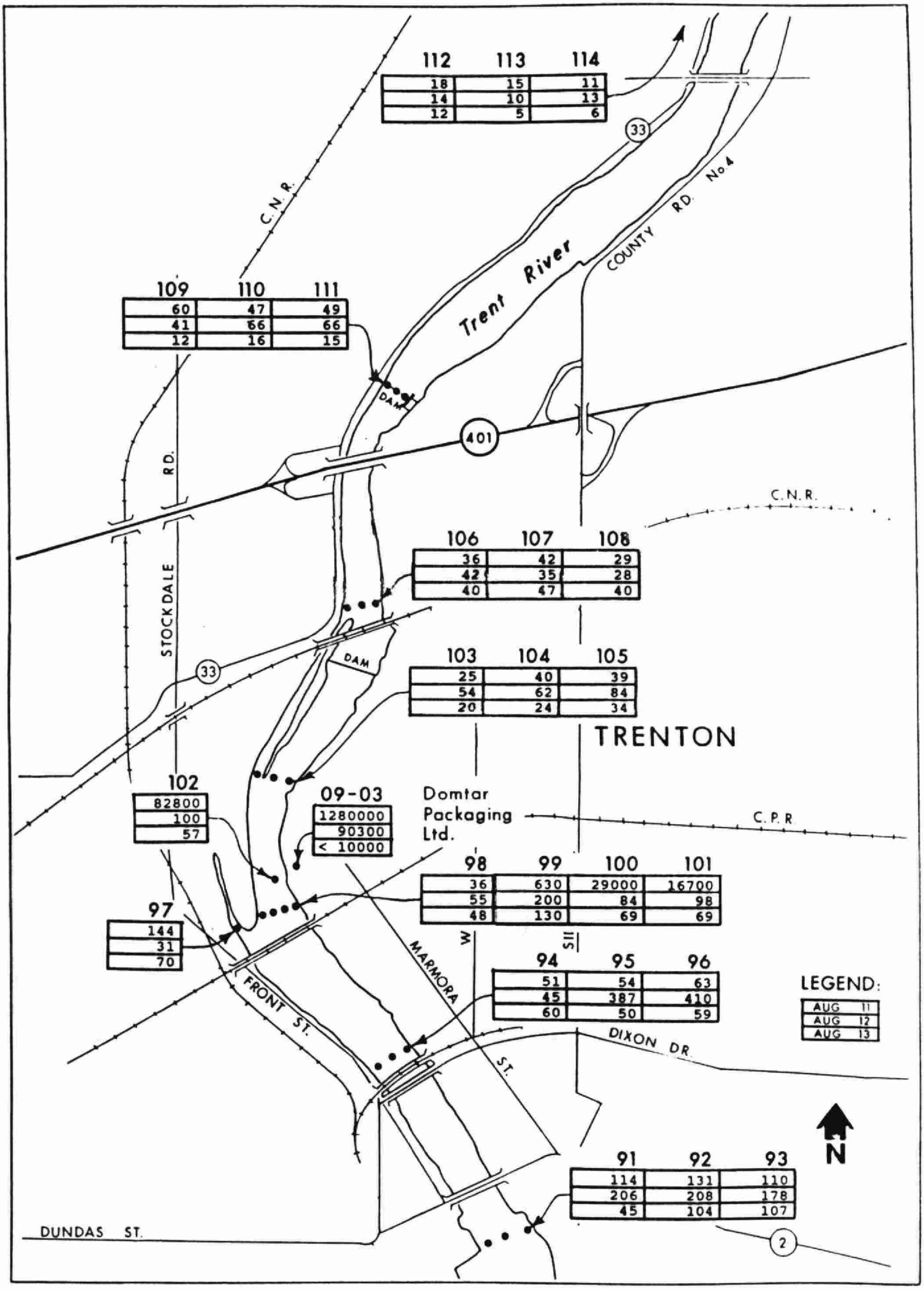

FIGURE 16: Fecal coliform counts (#/100mL) in the Trent River at Trenton during dry weather, August 1987.

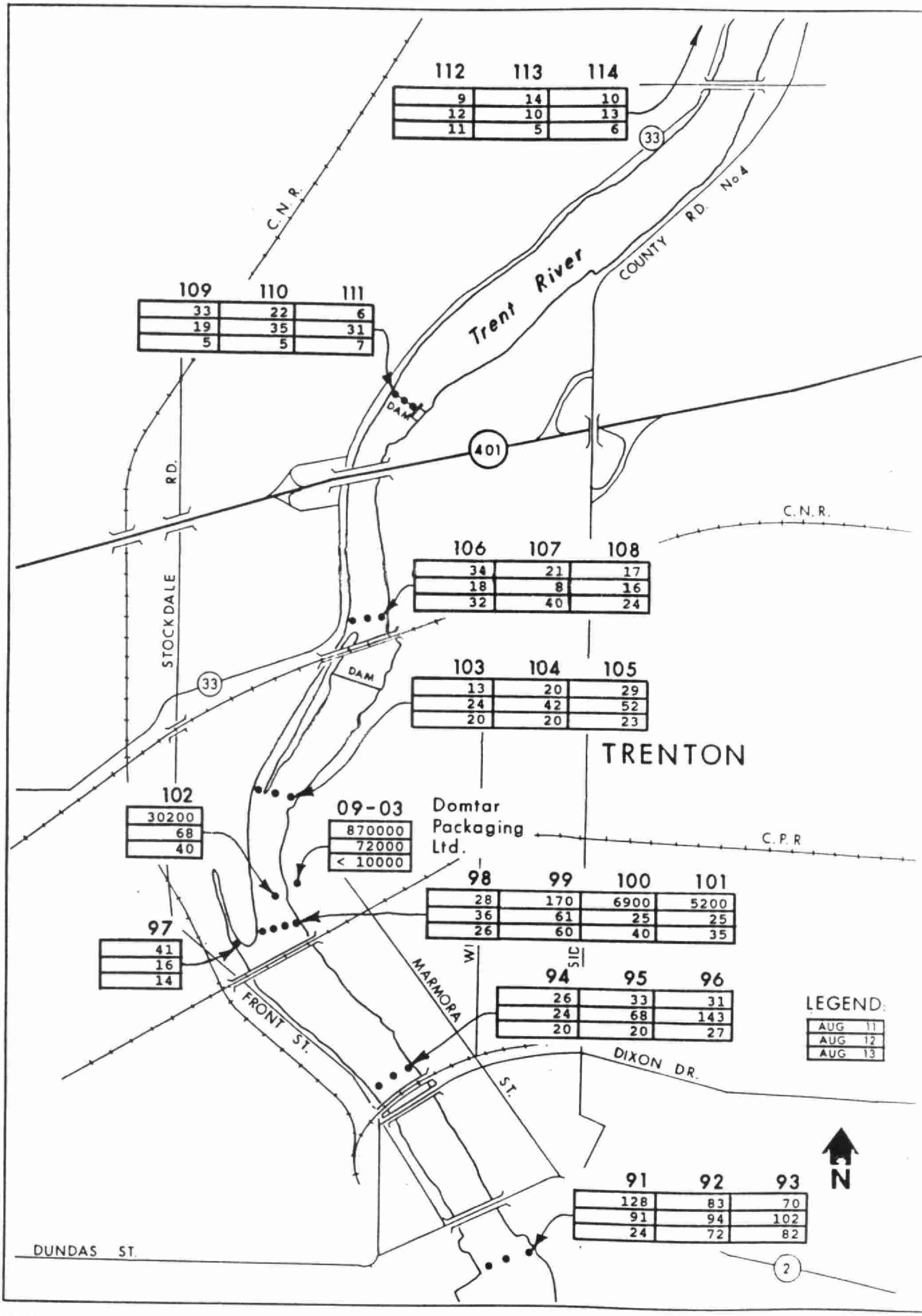

FIGURE 17: E. coli counts (#/100mL) in the Trent River at Trenton during dry weather, August 1987.

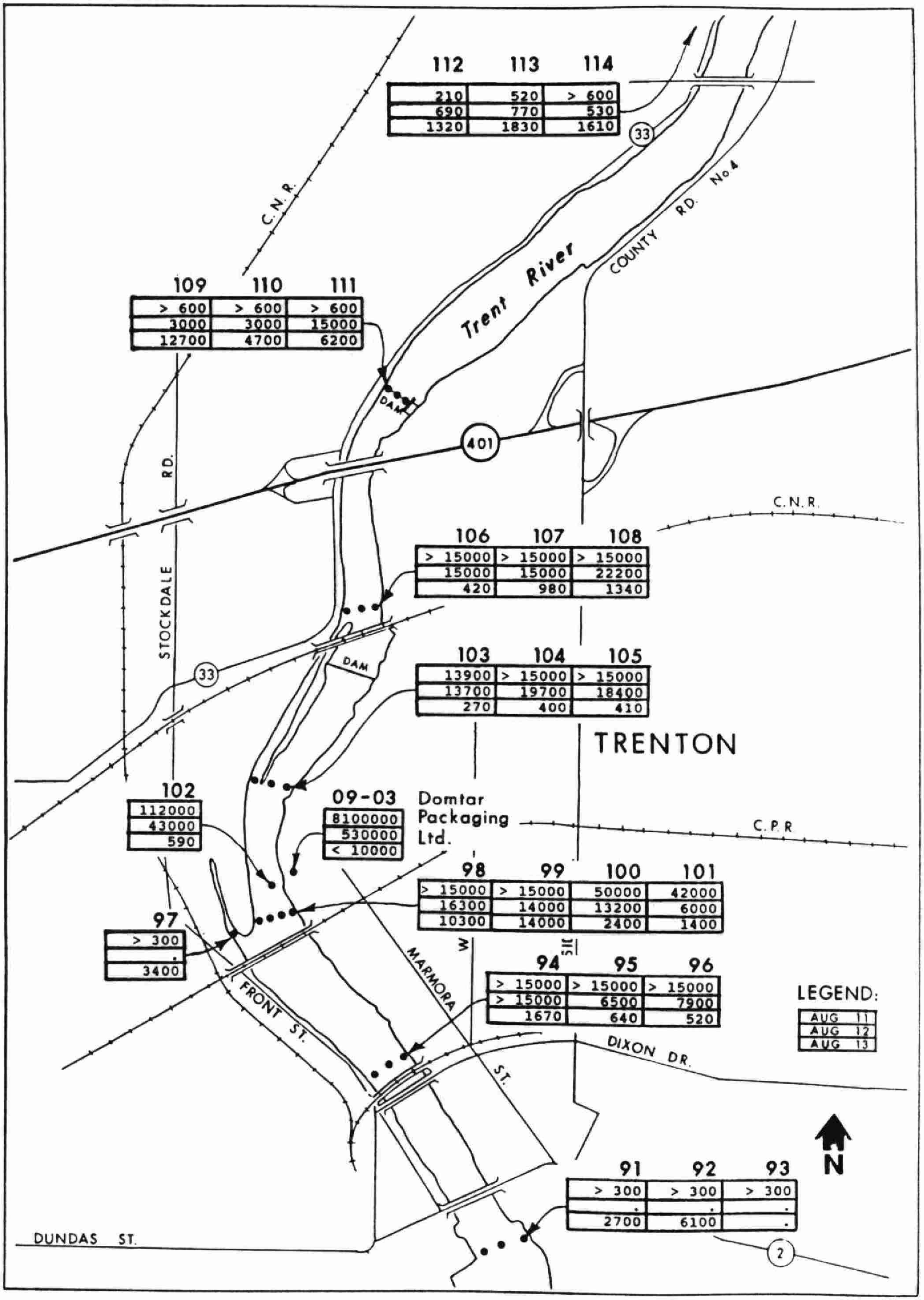

FIGURE 18: Klebsiella pneumonia counts (#/100mL) in the Trent River at Trenton during dry weather, August 1987.

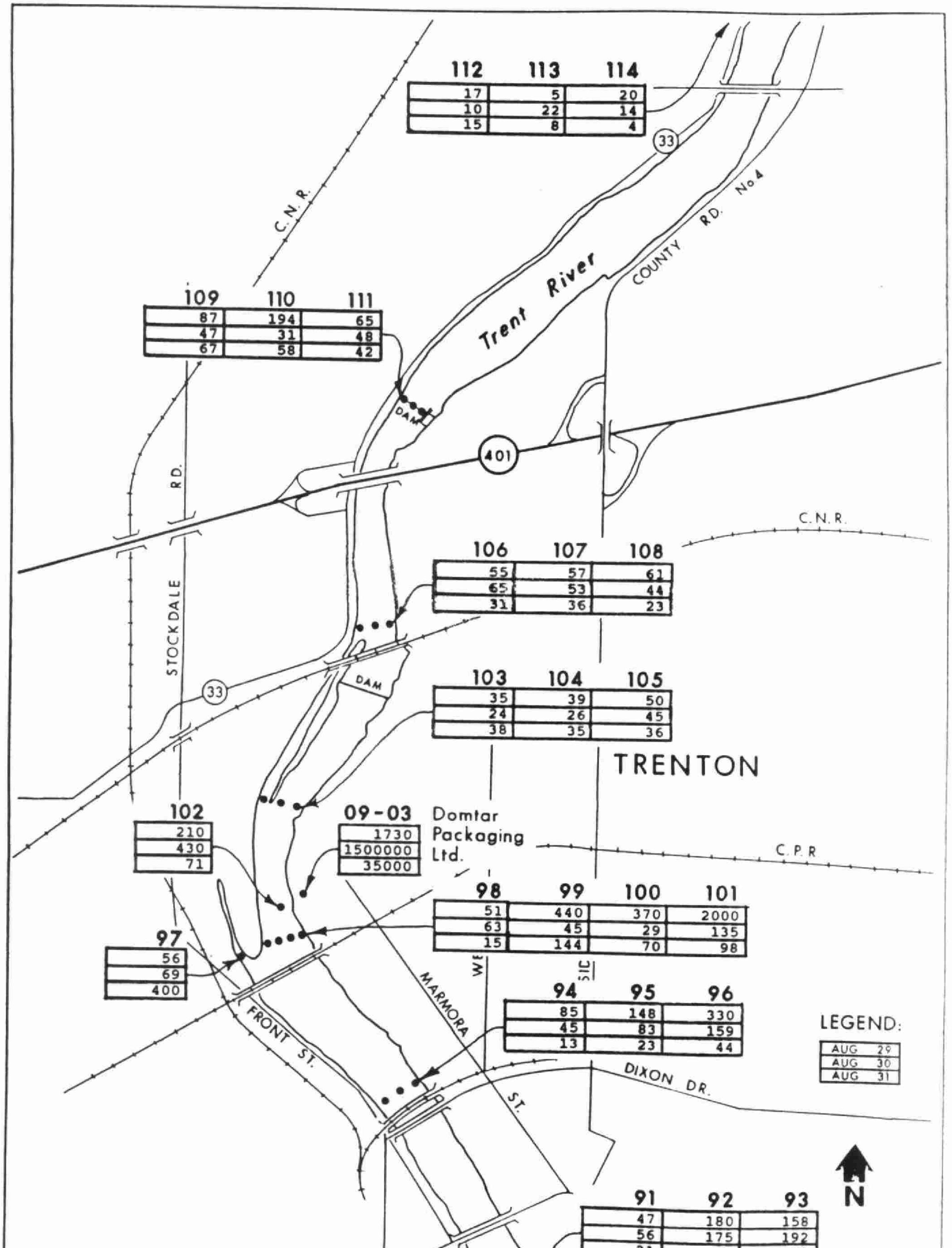

FIGURE 19: Fecal coliform counts (#/100mL) in the Trent River at Trenton during wet weather, August 1987.

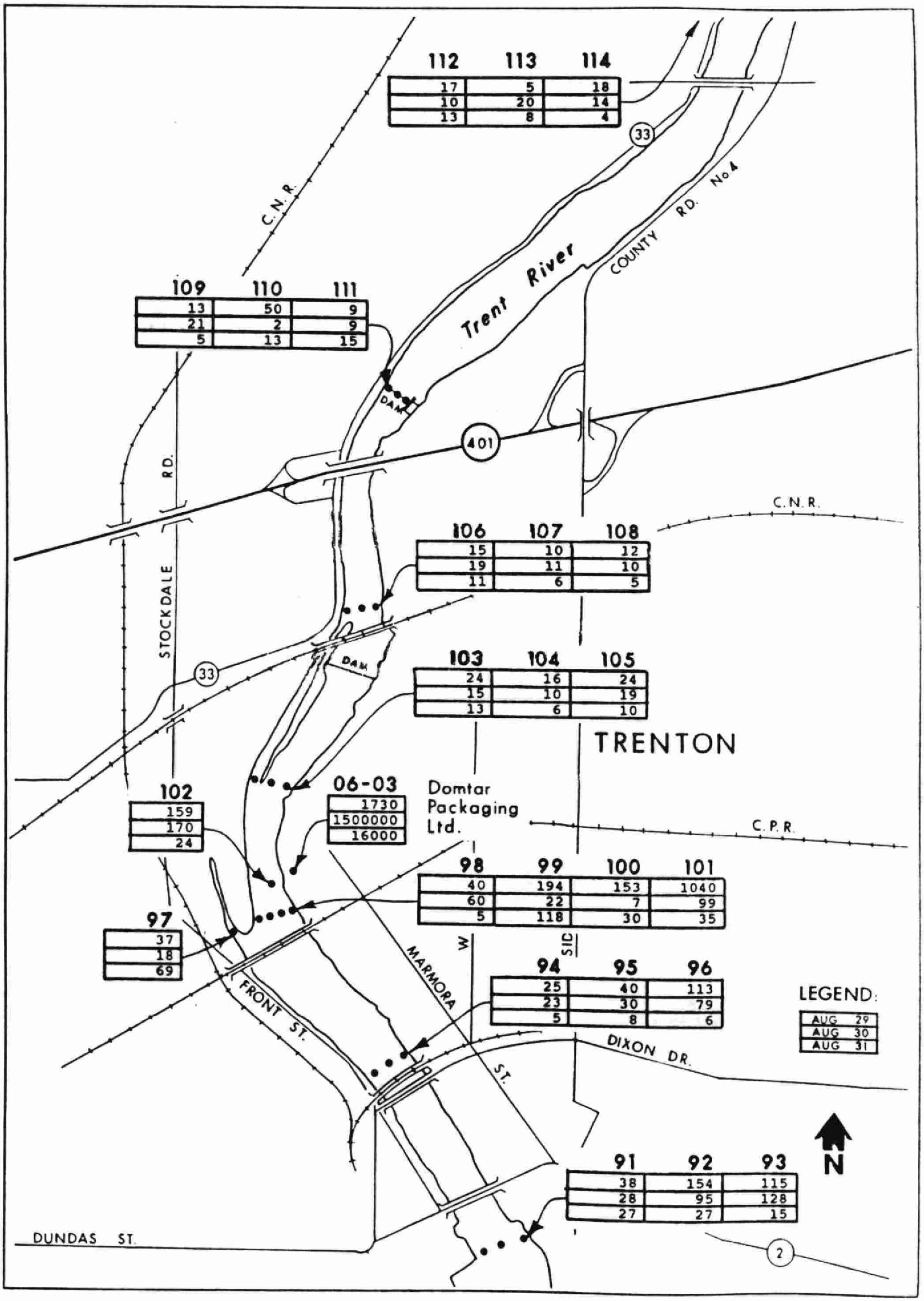

FIGURE 20: E. coli counts (#/100mL) in the Trent River at Trenton during wet weather, August 1987.

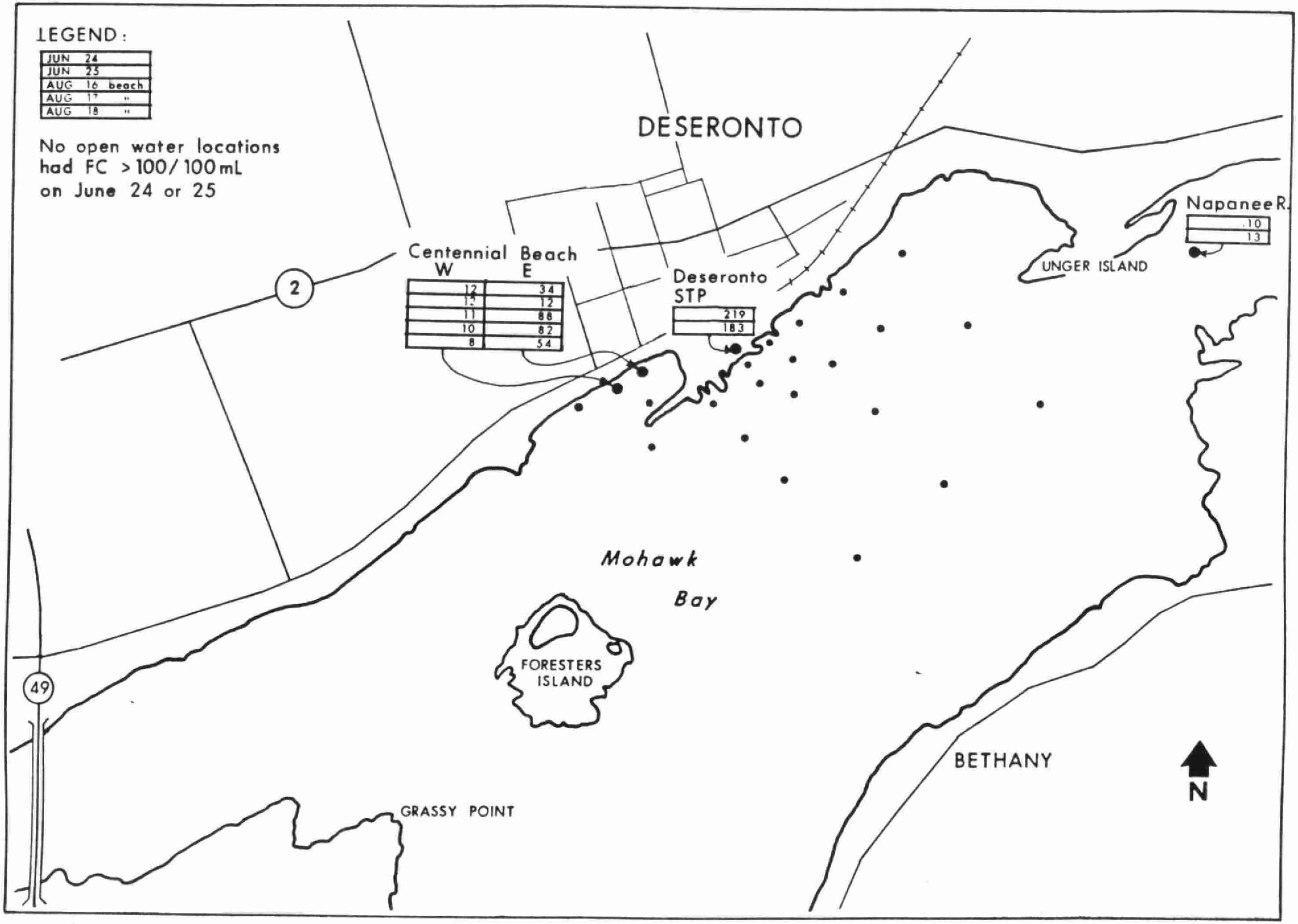

FIGURE 21: Dry weather fecal coliform counts (#/100mL) observed in 1987 at Deseronto.

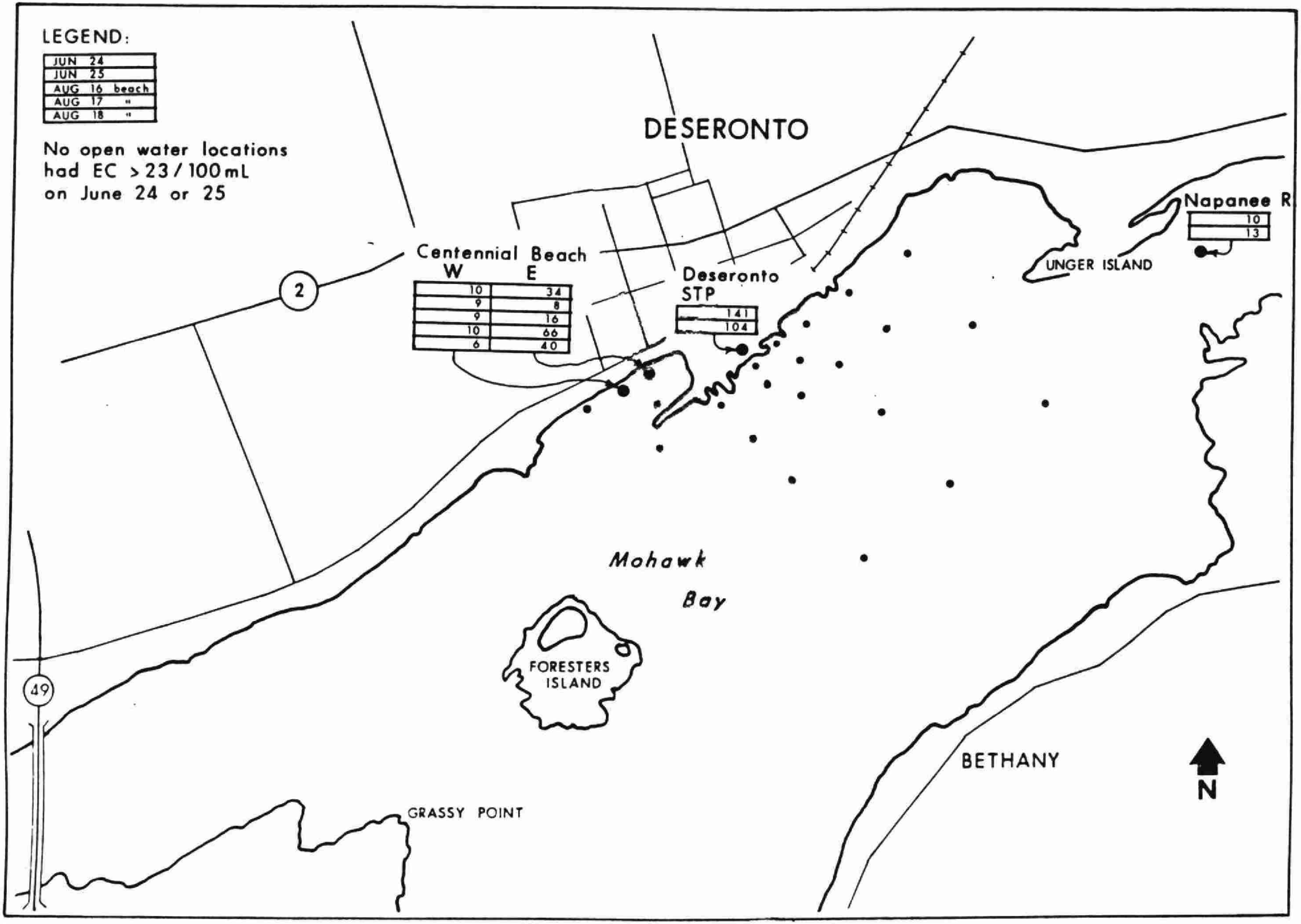

FIGURE 22: Dry weather E.coli counts observed in 1987 at Deseronto (#/100mL)

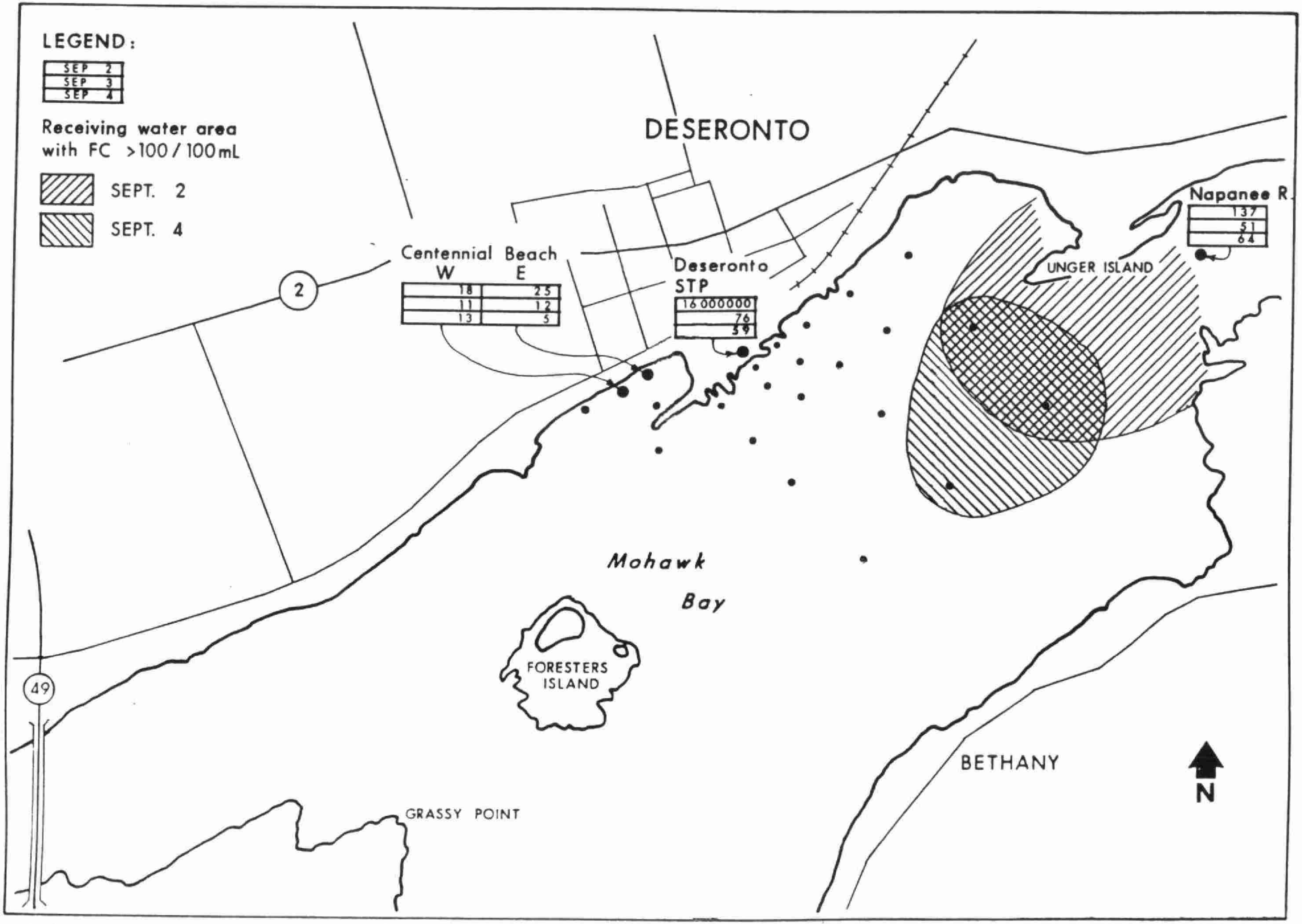

FIGURE 23: Wet weather fecal coliform counts (#/100mL) observed in 1987 at Deseronto

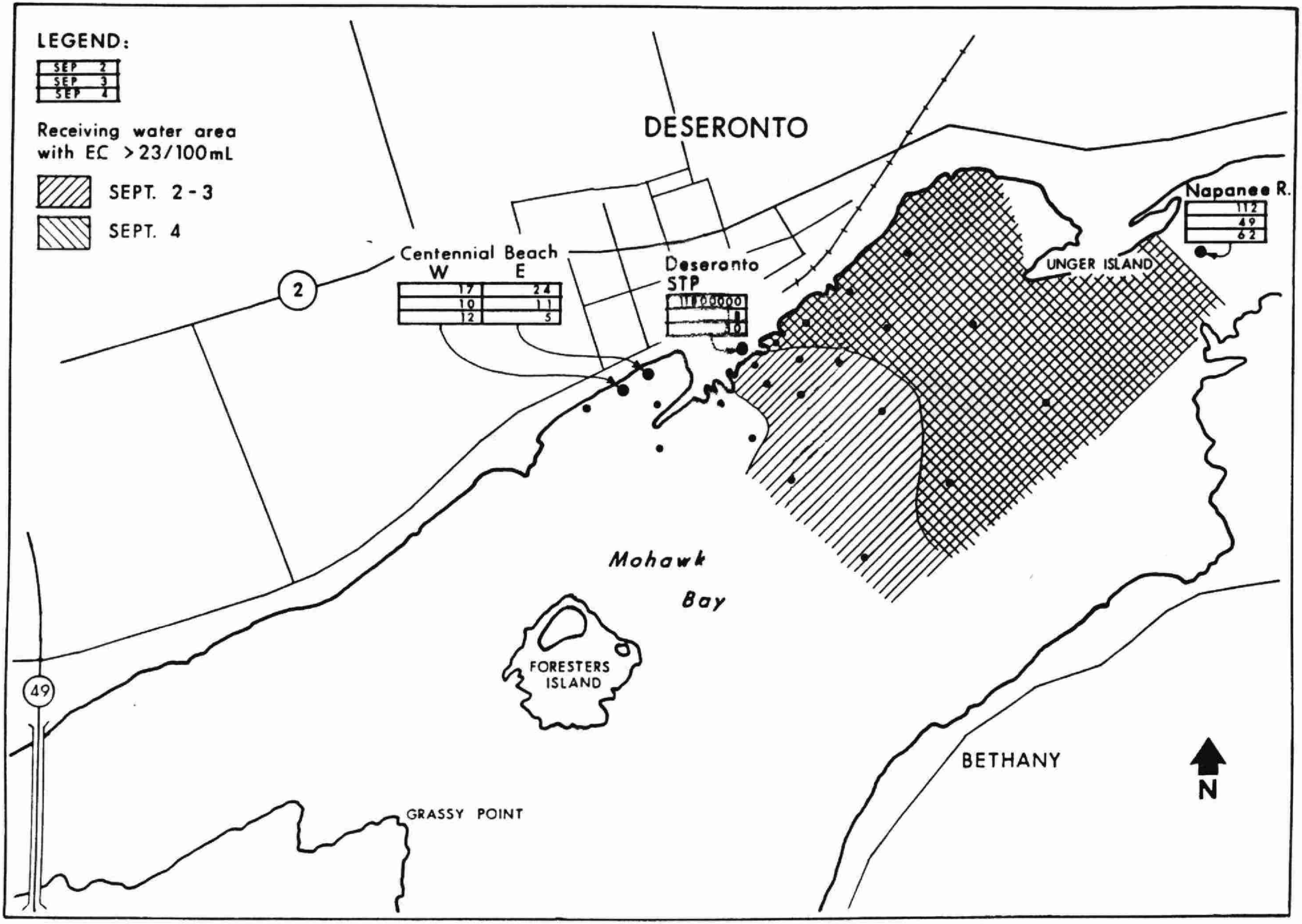

FIGURE 24: Wet weather E.coli counts (#/100mL) observed in 1987 at Deseronto.

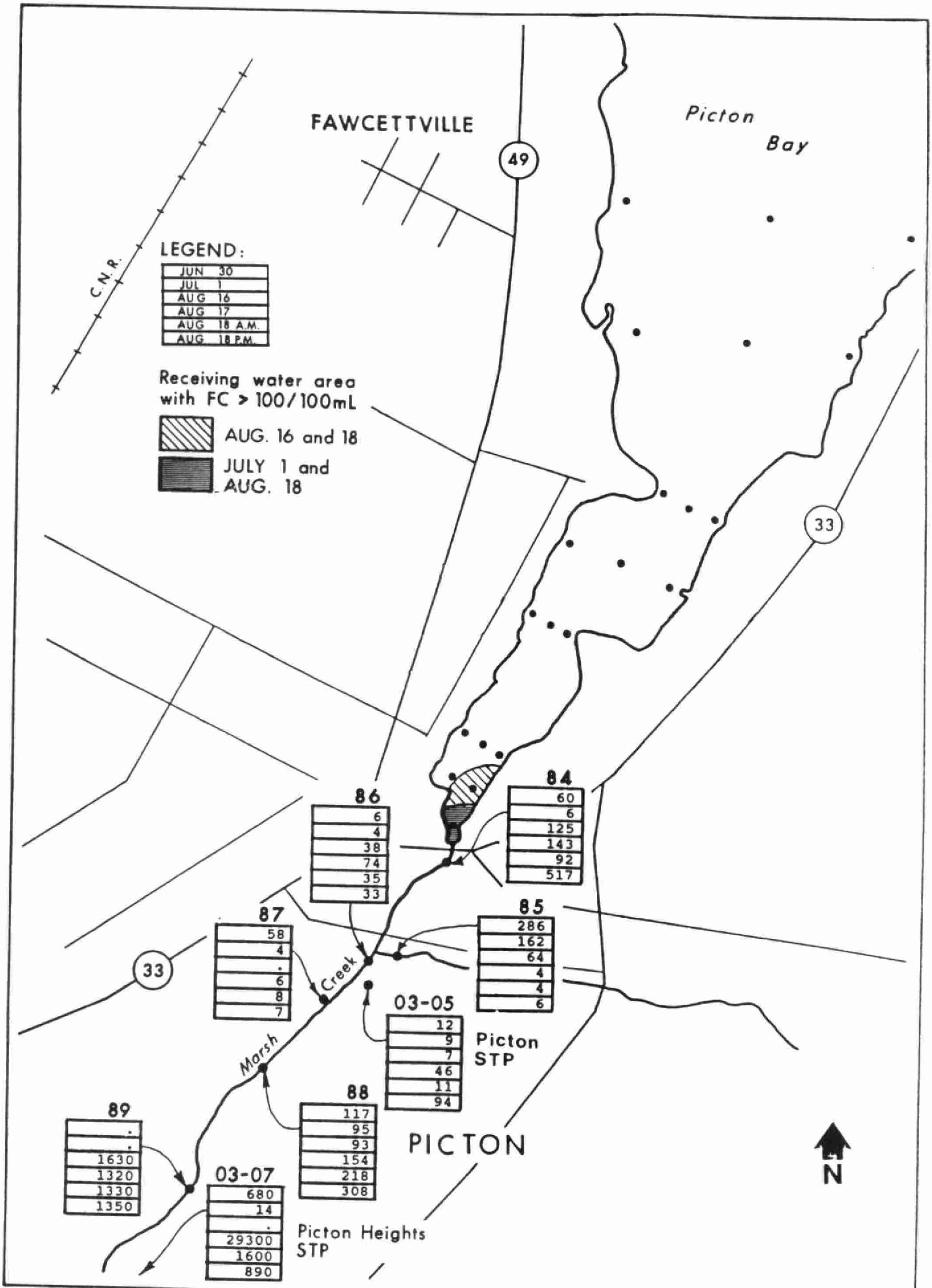

FIGURE 25: Dry weather coliform counts (#/100mL) observed in 1987 at Picton.

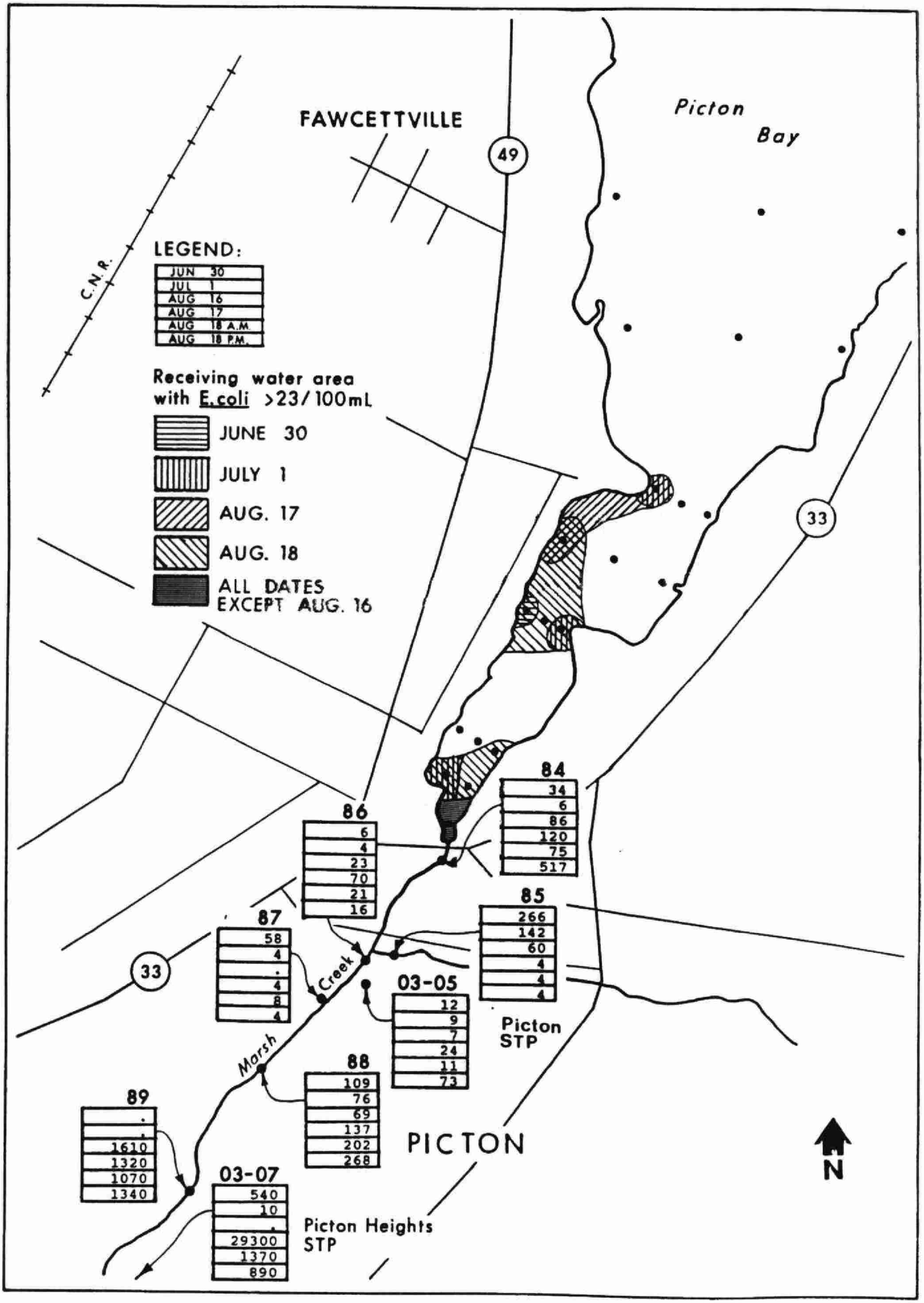

FIGURE 26: Dry weather E.coli counts (#/100mL) observed in 1987 at Picton.

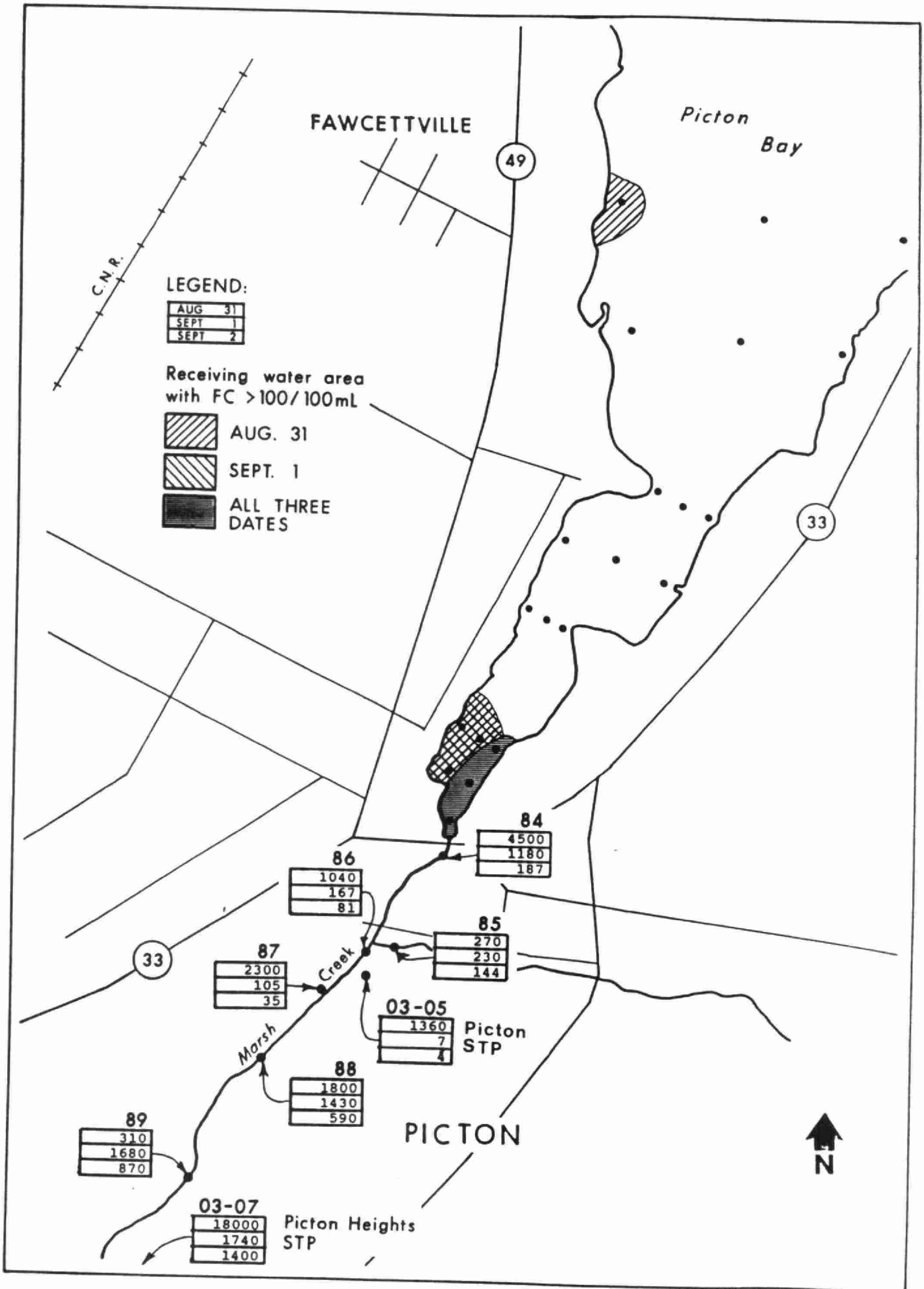

FIGURE 27: Wet weather fecal coliform counts (#/100mL) observed in 1987 at Picton.

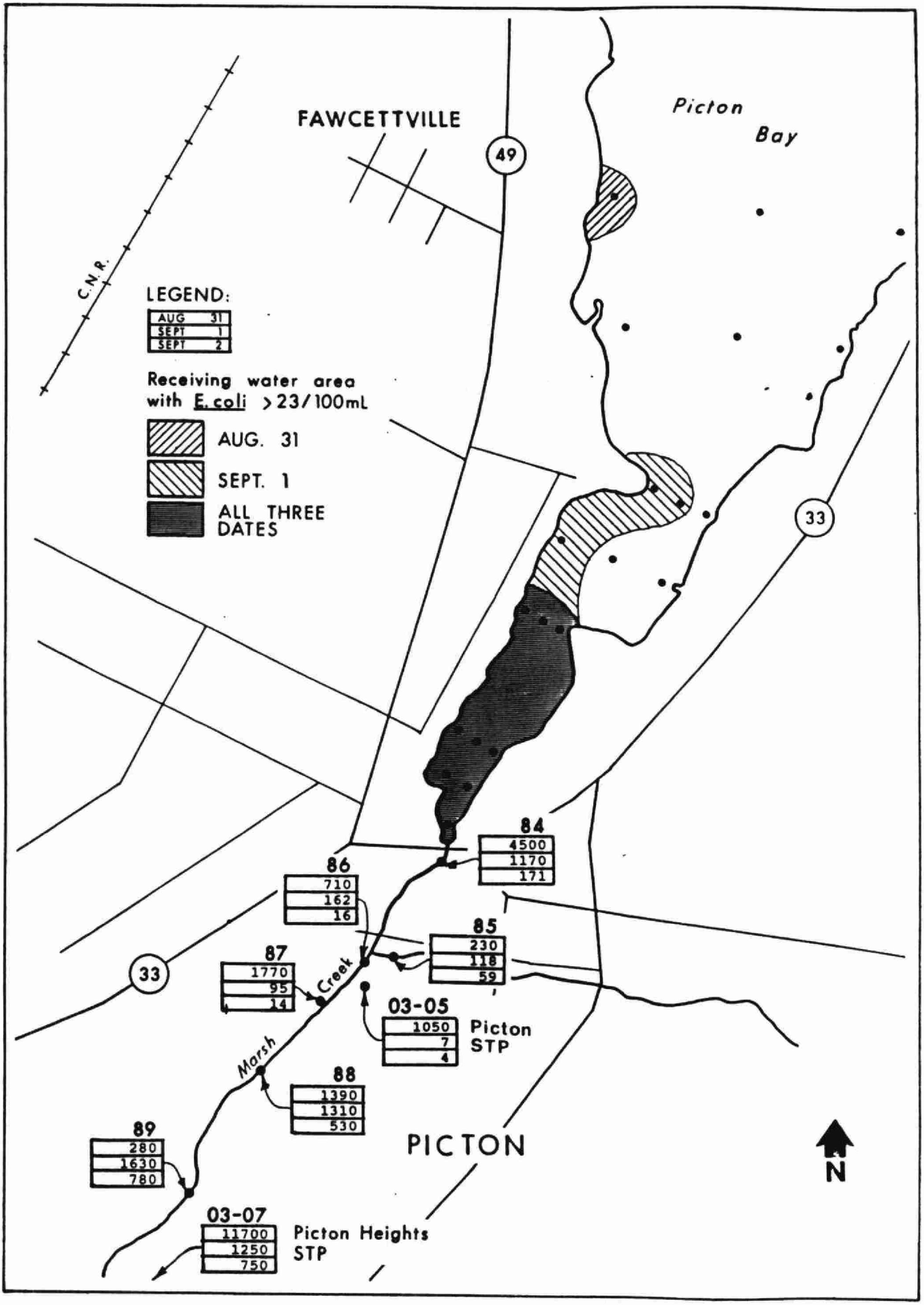

FIGURE 28: Wet weather E. coli counts (#/100mL) observed in 1987 at Picton.

Date Due

Remedial Action Plan
Plan d'Assainissement

Canada Ontario

Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs